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"CONSERVATION OF WILD LIFE THROUGH EDUCATION"

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TABLE OF CONTENTS

PAGE

A LIFE HISTORY STUDY OF THE CALIFORNIA QUAIL, WITH RECOMMENDATIONS FOR ITS CONSERVATION AND MANAGEMENT ---------- *E. Lowell Sumner, Jr.* 167

EDITORIALS ---------- 257

REPORTS—

VIOLATIONS OF FISH AND GAME LAWS ---------- 265

STATEMENT OF EXPENDITURES ---------- 267

STATEMENT OF REVENUE ---------- 270

FRESH FISHERY STATISTICS ---------- 271

A LIFE HISTORY STUDY OF THE CALIFORNIA QUAIL, WITH RECOMMENDATIONS FOR ITS CONSERVATION AND MANAGEMENT

By E. LOWELL SUMNER, JR.

PART I

INTRODUCTION

During the last fifty years the California quail (*Lophortyx californica* and its races) has suffered a marked decline in numbers throughout most of the state, in spite of considerable effort, chiefly in the

form of restrictive legislation, directed toward the protection of this species.

At the present time the Division of Fish and Game is engaged in a state-wide program of quail refuge establishment, which results in an acute need for information concerning the habits and requirements of the birds, so that an outline of management for California quail is more to be desired than ever before.

Accordingly, in July, 1931, the writer was assigned by the Division to a study of the life history of the California quail, with special reference to its conservation and management. The investigation was established upon a fellowship basis and has been carried on as a coöperative project between the Division of Fish and Game and the University of California, under the supervision of Dr. Joseph Grinnell,

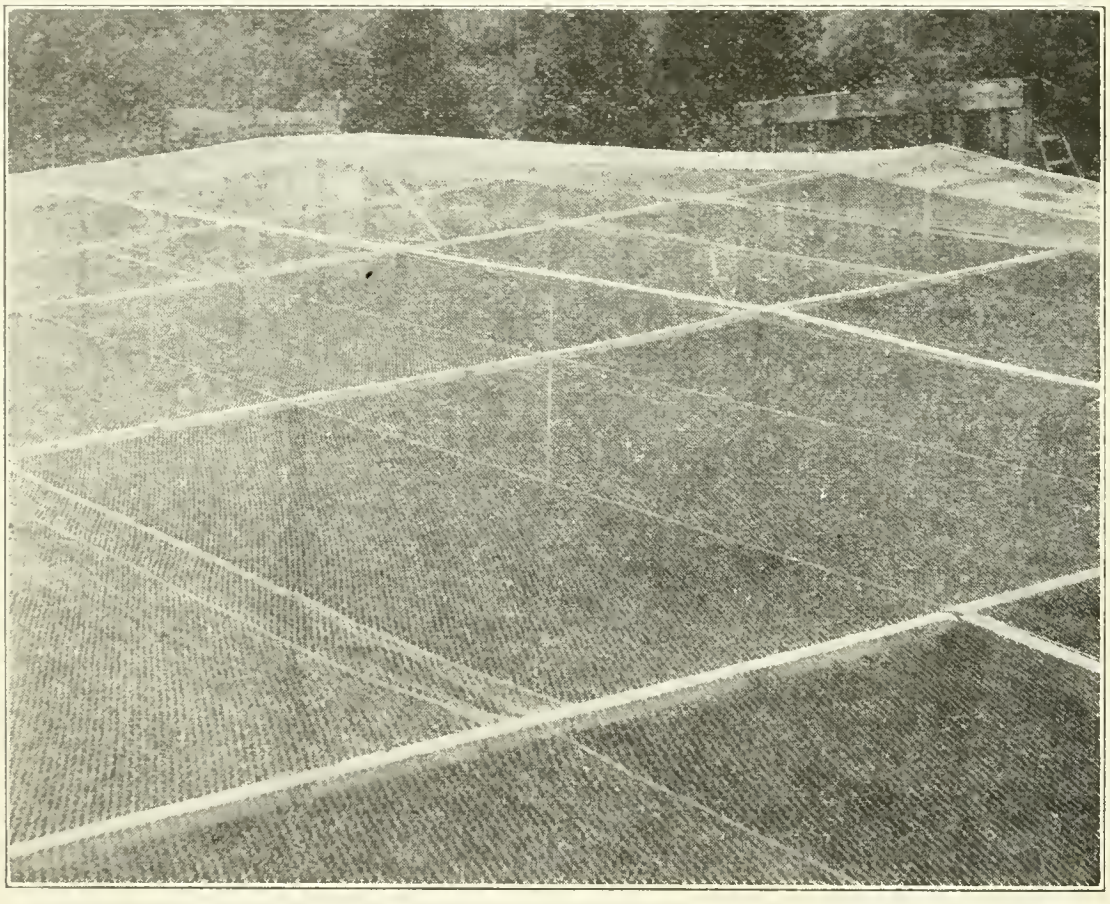

FIG. 1. Portion of the large open-air inclosure used during the present investigation for observation of certain habits of quail which are practically impossible to study when the birds are unconfined. Shows combination laboratory and observation blind at upper right.

Director of the Museum of Vertebrate Zoology of the University. Financial support has been given by the Division of Fish and Game, and the work has also received the general supervision of the division's Bureau of Education and Research.

ACKNOWLEDGMENTS

The following persons have aided in identifying certain food items found in quail stomachs: Mr. W. L. McAtee of the United States Bureau of Biological Survey; Dr. R. V. Chamberlin of the University of Utah; Dr. Charles Piper Smith, Dr. Herbert L. Mason, Dr. William

B. Herms, and Dr. J. F. Lamiman of the University of California. Mr. Gordon H. True, Jr., has assisted in securing materials and information from quail refuges in southern California. Mr. Jack Okell and Mr. James Rolph III have generously placed their properties at the disposal of the writer for the quail investigation. The estate of Mr. Rolph was used as a permanent field headquarters.

To Dr. Joseph Grinnell, Dr. Jean M. Linsdale and Dr. E. Raymond Hall the writer wishes to express appreciation for the helpful counsel and many suggestions received. Grateful acknowledgment is also due to Mrs. E. Lowell Sumner, Jr., whose constant help both in the field and in the laboratory would be difficult to overestimate.

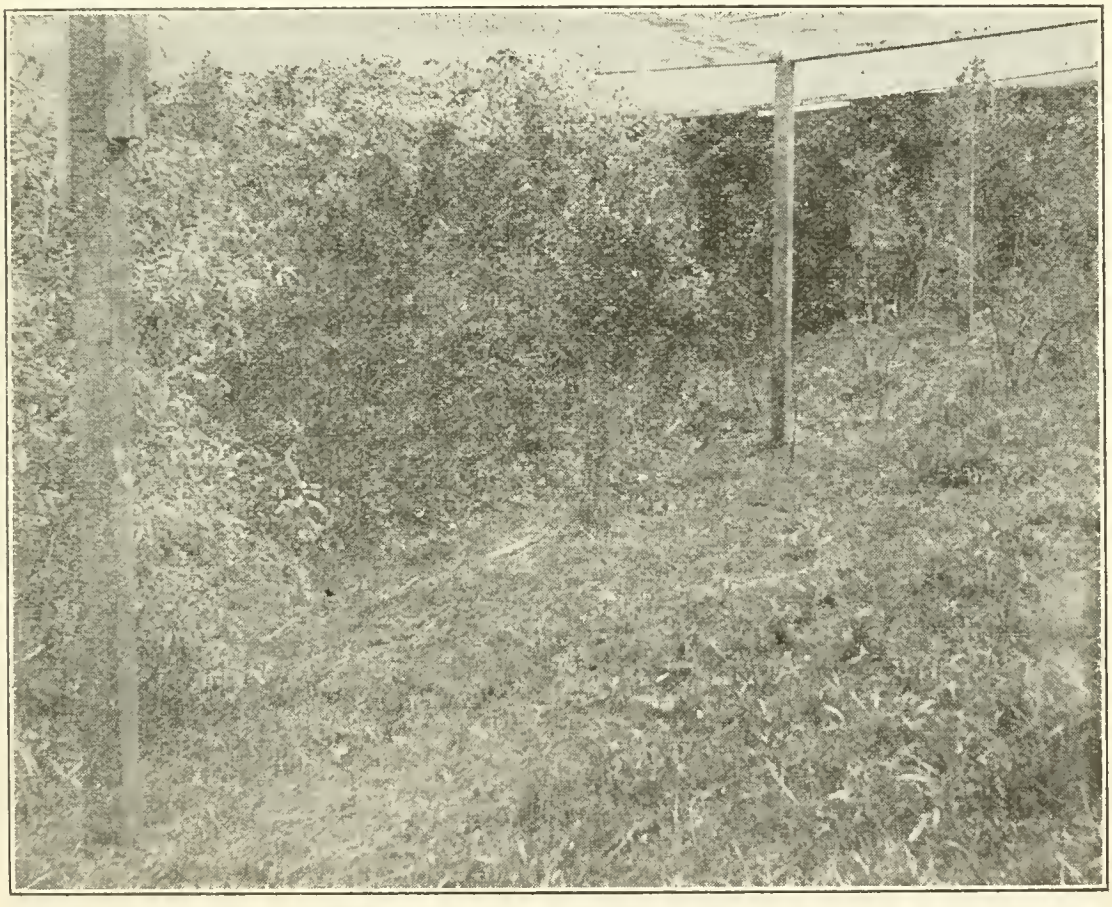

FIG. 2. Part of the interior of the inclosure shown in Fig. 1; all native plants were left undisturbed.

MATERIALS AND GENERAL METHODS

Most of the information upon which the present report is based was obtained by the writer as a result of 30 months of field work in a selected area 50 miles south of San Francisco, in the Santa Cruz Mountains, San Mateo County, California, while trips were also taken to other parts of the state to obtain data on local conditions. In addition to the observation and collection of quail in a free condition, it was necessary to build a large open-air inclosure provided with an observation blind for the study of certain habits of quail which were practically impossible to observe in a state of nature on account of the secretiveness of the birds. The blind was made large enough to serve as a small field laboratory, and was provided with living quarters enabling the observer to remain at his post for a week or more at a time (Figs. 1–2).

A total of 170 adult quail was collected during every season in the year for stomach examination and related purposes, and in addition, nine small young. To facilitate identification of stomach contents, a collection of local plants, with their seeds and fruits, was made. The relatively few food items which could not be identified by means of this collection were submitted to various authorities for determination.

An intensive trapping and banding program was also carried on uninterruptedly for more than a year, during which 280 individuals of all ages were captured 1107 times.

The subspecific race of California quail occurring in the Santa Cruz Mountains and elsewhere along the humid coast region of California has been designated as the coastal California quail (*Lophortyx californica brunnescens*) by Grinnell (1931, p. 37). Although there is some slight difference between this race and the more widely distributed Valley quail regarding plumage, together with a difference between their respective habitats as to humidity, the habits of the two birds are believed to be essentially the same, as are also the principles involved in their management. Accordingly, in the following report the two races will be considered together as one species except where it is specifically stated otherwise.

The original field notes taken by the writer during this investigation, and also the collection of quail stomachs which furnished the material for the section on food habits, have been deposited in the Museum of Vertebrate Zoology, where they may be consulted by persons interested.

PLAN OF TREATMENT

Part I of this report presents the original information obtained by the writer on the natural history of the California quail, and provides most of the foundation for the recommendations given in Part II.

Part II attempts to summarize all that is now known regarding the management of the California quail. Although largely dependent upon the preceding section on life history as a basis for recommendations, Part II also includes reference to certain important findings and outlines of policy arising from game studies conducted by investigators in the eastern United States.

PART I—LIFE HISTORY

FOOD HABITS AND REQUIREMENTS

Stomach Collection Represents Each Season of the Year. The writer attempted to collect a minimum of five quail stomachs from the Santa Cruz Mountain area for each month of the year, in order to determine seasonal changes in the diet of the birds. However, in spite of the most strenuous and prolonged exertions, the impenetrable nature of the brush land which occupies most of the quail country in the region studied, together with the wariness of the birds, made the strict attainment of this ideal impossible. When the number of birds fell short of the quota, it was necessary to take a compensating number of extra specimens during the first few days of the following month. Because of the resulting unevenness of distribution, certain months have been combined into bi-monthly periods in Table 1, which summarizes the food habits of the birds examined.

Heavy Grazing Results in Inferior Quail Food. In addition to a total of 74 quail collected from the Santa Cruz Mountain area, where grazing was light, an additional 28 birds were taken from a rather heavily grazed region in the foothills of southern Napa County. In Table 1 the figures for the two lots of stomachs have been combined and are indistinguishable; however it is doubtless significant that the stomachs of fourteen quail collected from the lightly grazed area during November and December contained 45 species of food plants, whereas 28 stomachs taken during the same months from the heavily grazed region contained only 19 species of food plants.

Of additional significance may be the fact that in November poison oak (*Rhus diversiloba*) constituted .027 per cent of the food of quail in the lightly grazed area, while in the case of the birds from the heavily grazed region it amounted to 6.11 per cent of the total food eaten. Errington (1931, pp. 7, 8) has found that fleshy fruits such as those of the genus *Rhus* are markedly inferior as food for bobwhite quail and are only eaten in quantity after the supply of more nutritious foods approaches exhaustion.

KINDS AND RELATIVE AMOUNTS OF FOODS

FOOD OF ADULTS

Materials. Table 1 summarizes the character and seasonal variation of the food of 102 adult California quail examined by the writer. Since the data from 28 stomachs collected during November and December on a heavily grazed area in Napa County were included with those from stomachs taken on the main study area, which was only lightly grazed, the unusually high percentage of bur clover shown in the table for these two months strikingly reflects the lack of variety in the food available to the birds living in the overgrazed region.

Methods. Because of the great amount of labor involved in the "percentage-by-bulk" method of separating the numerous food items

TABLE 1

MONTHLY AND YEARLY PERCENTAGES OF VARIOUS FOODS EATEN BY 102 ADULT CALIFORNIA QUAIL

	January	February	March	April and May	June and July	August and September	October	November	December	Yearly Average	Number stomachs in which item occurred
Number of stomachs examined	4	4	3	12	14	17	6	26	16		
VEGETABLE FOOD:											
Leguminosae (Pea family)											
Bur clover (*Medicago hispida*)*	2.82	11.00	10.59	19.59	.89	1.14	9.94	43.43	29.98	14.51	80
Feather acacia (*Acacia decurrens*)*			37.48	.13		4.66	.15	2.45	3.07	5.33	21
Lupine (*Lupinus formosus*)	17.48				10.65	1.82	6.31	2.37		4.29	21
Lupine (*Lupinus variicolor*)	7.64								15.38	2.56	5
Acacia (*Acacia*—2 additional species)*		6.14		.13			5.96			1.36	4
Lupine (*Lupinus succulentus*)	.20				6.75	.70		1.62	.15	1.05	10
Pinole clover (*Trifolium bifidum*)	.01			4.80	.25	.21	.50	Trace	Trace	.64	18
Spanish clover (*Lotus americanus*)					.59	4.42				.56	8
Hill lotus, or subpinnate lotus (*Lotus humistratus*, or *L. subpinnatus*)	.04			.01	.39	.05	4.13	.02	Trace	.52	18
American vetch (*Vicia americana*)							4.17			.46	1
Bird's-foot trefoil (*Lotus* sp.)	.03				3.06	.13	.10	.43		.42	11
Tomcat clover (*Trifolium tridentatum*)	Trace			2.60	.10	.16	Trace			.32	8
Scotch broom (*Cytisus scoparius*)*						1.12		.12		.14	4
Alfalfa (*Medicago sativa*)*					.50	.47		.003	Trace	.11	3
Spanish broom (*Spartium junceum*)*				.20		.16		.34	.11	.09	8
Sour clover (*Trifolium fucatum*)*	.05				.74	.01				.09	3
Deer-weed (*Lotus scoparius*)								.06		.01	1
Clover (*Trifolium*—3 additional species)				.02				.07	.02	.01	10
Wild pea (*Lathyrus vestitus?*)						.02				Trace	1
Gramineae (Grass family)											
Cultivated barley (*Hordeum vulgare*)*	26.06	53.62				32.34		7.37	.27	13.43	15

Italian or Australian rye grass (*Lolium multiflorum*)*	.71	6.00	2.50	3.60	19.82	7.67	1.54	1.73	.29	4.87	38
Brome grass (*Bromus hordeaceus*)*	2.88	6.33	2.50	3.60	.05	3.67	14.26	3.67	6.21	4.80	35
Cultivated red oats (*Avena sativa*)*	.22					.18	.40	.72	5.79	.81	21
Wild oats (*Avena fatua*)*	.04			.18	.89		.94			.21	4
Fescue (*Festuca* sp.)					.01	.28	.35	.01	.45	.12	14
Canary grass (*Phalaris* sp.)*					.39					.04	1
Darnel (*Lolium temulentum*)*				.05		.12				.02	2
Wild barley (*Hordeum pusillum*)						.09		.01		.01	2
Blue grass (*Poa annua*)*					Trace					Trace	1
Geraniaceae (Geranium family)											
Red-stem filaree (*Erodium circutarium*)*	.05		10.59	8.64	7.69	5.99	14.02	4.04	11.00	6.89	39
Common wild geranium (*Geranium dissectum*)*	.03				1.33	2.46	.50	1.58	.06	.66	30
Compositae (Sunflower family)											
Napa thistle (*Centaurea melitensis*)*	.01				2.71	7.38	4.97	1.42	.01	1.83	36
Chile tarweed (*Madia sativa*)					12.73	2.08	.25	.46		1.85	24
Tarweed (*Hemizonia congesta*)						5.68	.94	4.99		1.29	8
(*Microseris douglasii*)					1.89					.21	2
Prickly sow-thistle (*Sonchus asper*)*					1.58			Trace	Trace	.18	7
Mayweed (*Anthemis cotula*)*						1.21			.30	.17	6
Common false dandelion (*Agoseris plebeia*)					.81	.51	.03	.02		.15	7
Coyote brush or chaparral broom (*Baccharis pilularis*)						Trace	.10		1.28	.15	7
Tarweed (*Lagophylla ramosissima*)					.23	.11				.04	3
Annual false dandelion (*Agoseris heterophylla*)					.01	.28				.03	5
Milk thistle (*Silybum marianum*)*				.10	.10	.05				.03	3
Prickly lettuce (*Lactuca scariola*)*						.16	.03	Trace		.02	6
Soliva sessilis?*						.15				.02	2
Common spikeweed (*Centromadia pungens*)									Trace	Trace	1
Red-stem grindelia (*Grindelia rubricaulis*)						.02				Trace	1
Tidy tips (*Layia* sp.)						.01				Trace	1

* Introduced plant species.

TABLE 1—Continued

MONTHLY AND YEARLY PERCENTAGES OF VARIOUS FOODS EATEN BY 102 ADULT CALIFORNIA QUAIL

	January	February	March	April and May	June and July	August and September	October	November	December	Yearly Average	Number stomachs in which item occurred
Ranunculaceae (Buttercup family)											
California buttercup (*Ranunculus californicus*)	31.37			4.40	.64	.19	.02	Trace	Trace	4.07	18
Rosaceae (Rose family)											
Christmas berry or toyon (*Photinia arbutifolia*)							3.68	.43	1.67	.64	9
Thimble-berry (*Rubus parviflorus*)					4.98					.55	8
Pyracantha (*Crataegus* sp.)*		2.80								.31	1
Cultivated blackberry (*Rubus* sp.)*						.12			.03	.02	3
Five finger (*Potentilla glandulosa*)					.10					.01	2
California blackberry (*Rubus vitifolius*)					.05					.01	1
Miscellaneous families											
Poison oak (*Rhus diversiloba*)	.16	.15					5.47	6.14		1.32	16
Pimpernel or poor man's weather-glass (*Anagallis arvensis*)*	.01				1.43	2.98	4.97	.43	.37	1.13	33
Snow berry (*Symphoricarpos racemosus*)	.04					.99	6.86	.03	.13	.89	12
Elderberry (*Sambucus glauca*)					.15	1.86				.22	4
Red sorrel (*Rumex acetosella*)*	.03				.69	.01	6.21		Trace	.77	8
Wire grass (*Polygonum aviculare*)*						.14		.21	.50	.09	8
Curly dock, or fiddle dock (*Rumex crispus*, or *pulcher*)*						.19			Trace	.02	3
Gamble weed (*Sanicula menziesii*)	.04				1.13	.23	.55	1.81	1.93	.64	34
Rattlesnake weed (*Daucus pusillus*)						Trace	Trace	.14		.02	7
Squaw-root (*Carum gairdneri*)	.10									.01	1
(*Caucalis microcarpa*)							.04			Trace	1
Common chickweed (*Stellaria media*)*				4.08		.10				.46	2

Mouse-ear chickweed (*Cerastium viscosum*)*				.49						.05	1
Catchfly (*Silene gallica*)*						.03	.01			Trace	4
Wild mustard (*Brassica* sp.)*	4.42					.01	.05	.04	1.75	.50	6
Winter cress (*Barbarea vulgaris*)*						.01				Trace	1
Common pepper-grass (*Lepidium nitidum*)				Trace						Trace	1
California poppy (*Eschscholtzia californica*)	.20				2.37	.26	.01			.32	9
Miner's lettuce (*Montia perfoliata*)					1.18	.84				.22	9
Wild portulaca (*Calandrinia caulescens*)						Trace		.03		Trace	3
Buckthorn weed (*Amsinckia douglasiana*)	.03				.69	.12				.09	6
Nievitas (*Cryptantha*)					.58					.06	3
Pop-corn flower (*Plagiobothrys nothofulvus*)	.05				.20					.03	4
Wild lilac (*Ceanothus* sp.)	.17	.01			.23	.65		.09		.13	8
Blue-eyed grass (*Sisyrinchium bellum*)						.01	.84	Trace	Trace	.10	5
Fuller's teasel (*Dipsacus fullonum*)*								.90		.10	1
Turkey mullein (*Eremocarpus setigerus*)	.16					.02		.65		.09	6
Morning-glory (*Convolvulus* sp.)	.13							.25		.04	3
Convallariaceae [?]					.23		Trace			.03	1
Madrono (*Arbutus menziesii*)	.09								.09	.02	5
Farewell to Spring (*Godetia* sp.)					.17					.02	1
Willow herb (*Epilobium paniculatum*)					Trace	Trace				Trace	2
Amaranth (*Amaranthus* sp.)									.05	.01	1
White pigweed (*Chenopodium album*)*						.05				.01	2
Wild heliotrope (Phacelia—4 species)					.03			Trace	Trace	Trace	4
Brodiaea (*Brodiaca*) *bulblet*?	Trace							Trace		Trace	2
Wax myrtle (*Myrica californica*)							Trace			Trace	1
Field madder (*Sherardia arvensis*)*	Trace							.03		Trace	2
Owl's clover (*Orthocarpus* sp.)	Trace									Trace	1
Gall						2.56				.28	1
Oak gall								.11		.01	1
Unidentified green leaf fragments	4.73	13.95	36.34	45.98	9.42	2.52	1.70	11.78	19.11	16.03	60
Totals	100.00	100.00	100.00	98.60	98.43	99.42	100.00	100.00	100.00	99.62	

* Introduced plant species.

TABLE 1—Continued

MONTHLY AND YEARLY PERCENTAGES OF VARIOUS FOODS EATEN BY 102 ADULT CALIFORNIA QUAIL

	January	February	March	April and May	June and July	August and September	October	November	December	Yearly Average	Number stomachs in which item occurred
ANIMAL FOOD:											
Common red ant (*Formica rufa*)				.88	.74	.15				.19	13
Ants (*Formica*—3 additional species)				Trace	.05	.07				.01	3
Carpenter ant (*Camponotus*)				.51						.06	2
Stink bug (Pentatomidae)					.49					.05	1
Bug nymph (Hemiptera)						Trace				Trace	1
Grasshopper (Locustidae)					.27					.03	1
Leafhoppers (Cicadellidae—adults and nymphs)					.02					Trace	1
Caterpillar (Lepidoptera)						.35				.04	1
Beetle (Coleoptera)						Trace				Trace	1
Western twelve-spotted cucumber beetle (*Diabrotica soror*)									Trace	Trace	1
Fly (Diptera)				Trace						Trace	1
Hover fly (Syrphidae)				.01						Trace	1
Unidentified insects					Trace	Trace		Trace		Trace	5
Solpugid (Solpugida)						.01				Trace	1
Totals	0	0	0	1.40	1.57	.58	0	0			
Feather barbules		Trace	Trace		Trace			Trace	Trace	Trace	10
Gravel (figures for gravel represent percentages of the *total* stomach contents)	5.39	13.18	28.90	38.95	7.90	9.67	5.94	10.19	8.26	14.26	102

in the heterogeneous food mass of a quail stomach (for example the separating of gravels and small seeds, imbedded in green leaf masses), it was found most practical to count the individual items without separating them in every case.

In order that the results of the investigation might be comparable with the work of others, however, the figures representing the number of seeds, insects, etc., were mathematically converted into the percentage-by bulk figures used by the U. S. Biological Survey (McAtee, 1912), and most other authors. The conversion was accomplished by first determining for each plant species the number of seeds contained in a cubic centimeter; then by means of these values the amount of each food item in a given stomach was expressed in terms of cubic centimeters; the total number of cubic centimeters of stomach contents was next found by simple addition; and finally the percentage of each food item in a given stomach was computed by dividing the number of cubic centimeters of each item by the total number of cubic centimeters of the stomach contents.

The percentage of gravel particles was first computed and this figure subtracted from the total stomach contents before the percentages of actual food materials were determined. The percentages of green leaf material could not be obtained by the counting method, and were roughly estimated as to volume in accordance with the customary percentage-by-bulk method.

Under "trace" is included percentages of .004 or less.

In the table the various families of plants are listed in order of decreasing importance as regards their consumption by quail. Of the green leaf fragments, only the unidentified pieces are listed separately from the other food items; when identified, which was in the majority of cases, such fragments are included under the same heading as the seeds or fruits of the food item in question. For a graphic record of the seasonal fluctuation in amount of *all* green leaf fragment material, see Fig. 4; statements of the relative proportions of leaf material to seed material in the case of the individual food items are given in the detailed treatment of the major food items below.

Instances where the percentages given in the present report differ from those given by earlier workers (Judd, 1905; Beal, 1910) are explainable upon the basis of differing local conditions and perhaps also because of the smaller number of stomachs involved in the present case. The present list adds 33 new kinds of vegetable food to the total of approximately 110 kinds previously recorded for the California quail.

Leguminosae. The pea family provides a larger and more varied food supply (32.47 per cent of the total food) for the California quail than does any other, and includes the most important forage plant of all, namely bur clover. It is doubtless not an accidental circumstance that the plants of this family, which play such an important part in the life of quail, are as nutritious as they are abundant.

Bur Clover. This introduced forage plant is common throughout California and is highly prized by stockmen because of its exceptionally high nutritive value at all seasons (Hart, Guilbert and Goss, 1932, p. 52). It is undoubtedly the most important single item in the diet of

quail throughout a large part of California. Table 1 and Fig. 3 show two seasonal peaks of consumption for bur clover, the first in April-May and the second in November.

The April-May consumption represents the height of the season during which the birds are forced to depend largely upon a green leaf diet because of the exhaustion of the seed supply of the previous fall. The November peak represents the season of maximum seed abundance. This species of clover is thus available to the birds throughout the year, especially during the critical winter period of food shortage.

In the fall and early winter months the burs are swallowed whole, but about January they commence to open and liberate their seeds which are thenceforth picked up individually by the birds. The aver-

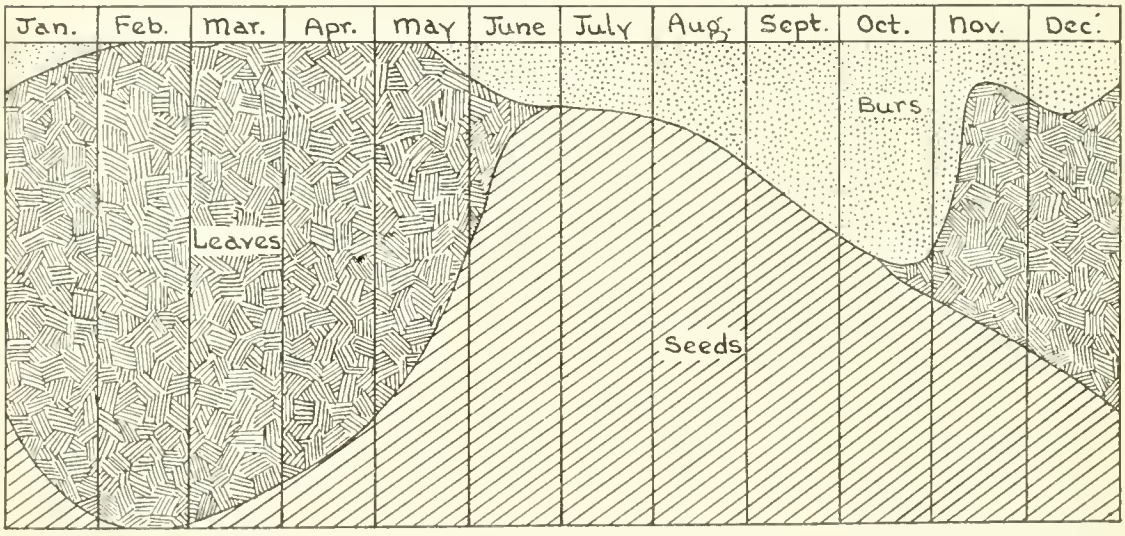

FIG. 3. Relative proportions of leaves, seeds, and burs of bur clover (*Medicago hispida*) consumed by the California Quail through the year.

age number of seeds of this species per stomach (excluding all stomachs which contained none at all) was 185; maximum 1224.

Other Peas. Other members of the pea family appear to be eaten roughly in proportion to their abundance. Cultivated trees of the genus *Acacia* furnish an important supply of quail food because, like bur clover, their seeds are available during the midwinter shortage. This would doubtless have been more clearly indicated in Table 1 but for the fact that no collections of quail were made in the vicinity of acacia trees during January.

Numbers Consumed. To give a better idea than is afforded by the table of percentages, of the quantities of individual seeds eaten by quail, the average and maximum numbers of seeds of certain common species is given: *Lupinus formosus*, 79, 376; *Lotus humistratus*, or *subpinnatus*, 23, 125; *Trifolium tridentatum*, 10, 63.

Gramineae. Cultivated grains make up 14.4 per cent of the food of quail in the region covered by the present study.

Barley. This item represented 13.30 per cent of the total food in the case of the present investigation because in the region under consideration hay is the major agricultural crop, with barley second in importance only to red oats.

The writer observed that for about three weeks a particular covey of quail habitually went to a newly sown barley field for its evening meal. The crops of birds shot from this covey at roosting time were enormously distended with barley kernels, the number averaging 162 per crop.

Although the barley taken from August to November was waste grain, this is only 33.3 per cent of all the barley consumed. The large size of the individual grains is, of course, partly responsible for the high percentage recorded for this food item.

Red Oats. Red oats constituted only .81 per cent of the food of quail in the region studied, in spite of the fact that at least twice as much oats as barley was sown there. The small amount of oats eaten doubtless results from the difficulty which the birds appear to have in swallowing the long pointed grains. As noted on page 190, even barley is difficult for quail to swallow, on account of its length, while oat grains are still longer. Only 17.7 per cent of the red oats consumed was waste grain.

Wild Grasses. Of the wild grasses, which form 10.07 per cent of the food of California quail *Lolium multiflorum* and *Bromus hordeaceus* are the most important in the region studied and, while not as consistently nutritious as bur clover (Hart, Guilbert and Goss, 1932, p. 52), they are nevertheless of great value as forage, and like the clover they furnish a food supply during the entire year. Average and maximum numbers of seeds per stomach (excluding all stomachs not containing any at all) were: *Lolium multiflorum*, 65, 592; *Bromus hordeaceus*, 32, 206.

Geraneaceae. The geranium family is third in importance, amounting to 7.55 per cent of all the food of quail.

Filaree. The filarees are valuable not only for their seeds, but also because in late winter they furnish an important source of green leaf material. As in the case of bur clover, there are two seasonal peaks of abundance, one in March representing green leaf materials and one in October representing the height of the seed crop. From the point of view of nutritive value the filarees are only a little inferior to bur clover (Hart, Guilbert and Goss, *op. cit.*, p. 52). Average and maximum numbers of seeds per stomach are 46 and 240.

Geranium. *Geranium dissectum* occurred in a large number of stomachs (average and maximum seed numbers per stomach 17 and 243), but the small size of the seeds results in an insignificant percentage by volume. The plant is of some importanee as a source of green food.

Compositae. The sunflower family ranks fourth in importance, and constitutes 5.84 per cent of the total food of quail..

Centaurea melitensis. The Napa thistle, a notorious and widespread agricultural pest, is the the most important of the group; however, like all of the Compositae listed, it appears to be largely unavailable to quail during the period of winter food scarcity.

Average and maximum numbers of seeds of the more important Compositae as they occur in quail stomachs are given below; an asterisk indicates that the seeds are not picked up one by one, but are

swallowed in quantity while still attached to the flower head: *Centaurea melitensis*, 55, 437; *Madia sativa* 125, 632; *Hemizonia congesta*, 368, 1190; **Microseris douglasii*, 63, 63 (one stomach only); **Anthemis cotula*, 248, 548; **Baccharis pilularis*, 1296, 5106.

Ranunculaceae. Although the seeds of the buttercup are eaten only sparingly, the plant is important because it furnishes a considerable amount of green leaf material during the period of winter scarcity. The blossoms are also habitually eaten by quail.

Rosaceae. All species of Rosaceae together amounted to only 1.5 per cent of the food during the present investigation. This may be due in part to the fact that the fruits of these plants are largely out of reach of such ground-foraging birds as quail. There is also a strong indication that berries are inferior in nutritive quality to the seeds of legumes, grass, and other weeds, and are of value chiefly as "salads" or "tonics."

Miscellaneous Families. The following species (listed with figures for average and maximum numbers per stomach) are eaten during the major part of the year, but because of the small size of the seeds they do not bulk large when expressed as percentages: *Anagallis arvensis*, 162, 748; *Rumex acetosella*, 257, 1819; *Brassica* sp., 208, 808.

Turkey mullein (*Eremocarpus setigerus*), elsewhere a favorite food of quail, was a rare plant in the region where the present study was carried on, which explains the small percentage recorded for it.

Although one might suppose that various trees and shrubs, especially those of chaparral, would provide an excellent food supply for quail, such is not the case. The following species (listed with figures for average and maximum numbers per stomach) are common in the region studied, and produce fruit in considerable quantities; nevertheless, as Table 1 shows, they are eaten by quail only sparingly: Poison oak, 16, 46; Snowberry, 9, 168; Elderberry, 40, 154; *Ceanothus* sp., 14, 38; Madroño, 11, 16; *Myrica californica*, 3, 3 (one stomach only).

Even when the shrubs included under Rosaceae are added to this list, the total percentage of tree and shrub fruits amounts to only 4.11 per cent of the total food.

Galls. In addition to the two galls listed in Table 1, a third, minute form occurred in the fleshy walls of nearly all of the poison oak seeds eaten by quail. This small gall (average long diameter 1.02 mm.) was thought by the writer to be part of the fruit wall until it was identified by the Division of Food Habits Research of the Bureau of Biological Survey; consequently no estimate of its numbers or aggregate bulk was made. However, its size was so small that it could not have rated as more than "trace."

Green Leaf Fragments. Green leaf fragments and similar succulent vegetation constitute an extremely important food for quail (35.36 per cent of total stomach contents). Although such materials are eaten during every month of the year, they are especially prominent in the diet during the winter months after most of the seed supply has become exhausted.

Relation of Green Leaf Material to Water Consumption. With the widespread disappearance of green materials following the advent of the dry season in June, consumption gradually dwindles, until a minimum of 3.43 per cent is reached in October. This is the season during which the birds are forced to depend upon springs or pools for their water requirments.

With the appearance of new vegetation following the first winter rains, consumption of green leaf material rises abruptly, which in turn results in a cessation of visits to the water holes.

Relation of Green Leaf Consumption to Seed Supply. As shown by the curve (Fig. 4), so long as the seed supply holds out it seems to be preferred to green leaf materials, and doubtless it is much more nutritious per unit of volume. The writer has seen penned birds gradually starve to death on a diet of green feed alone, while the birds showed an extraordinary eagerness for seeds whenever these

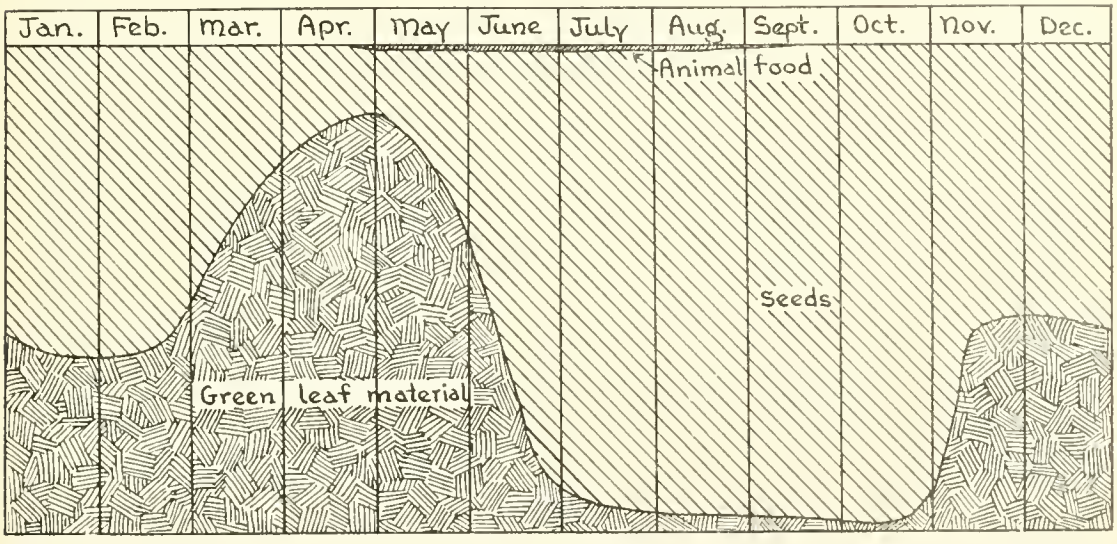

FIG. 4. Relative proportions of seeds, green leaf material and animal food consumed by the California Quail through the year.

were supplied. However, as the seed supply approaches exhaustion in January and February, the birds are forced more and more to depend upon green food, until by April and May it constitutes 85.49 per cent of their entire diet.

Possible Relation of Green Leaf Consumption to Reproduction. Dry winters such as that of 1933–34 (see page 237) work a hardship upon quail by checking the growth of an adequate supply of green forage, with the result that the birds are short of food and in poor condition just before as well as during the breeding season. Moreover, green vegetation is recognized by poultrymen as a source of vitamins which favor egg laying, so that it is possible that a vitamin deficieney may be partly responsible for the observed failure of quail to breed during exceptionally dry years.

The approximate percentages of the various items constituting the total of all green leaf materials consumed are as follows:

Bur clover, 19.1; unidentified fragments, 38.3; grasses (chiefly *Lolium* and *Bromus*), 20.4; buttercup, 10.8; filaree, 7.4; *Madia sativa*,

TABLE 2

PERCENTAGES OF VARIOUS FOODS EATEN BY YOUNG CALIFORNIA QUAIL

	Percent	Maximum number of item per stomach	Average number of item per stomach	Number of stomachs in which food item occurred
a. Age 2-3 days (4 specimens)				
Alfalfa (*Medicago sativa;* leaves only)	24.21			1
Beard grass (*Polypogon monspeliensis*)	1.05	8	8	1
Common wild geranium (*Geranium dissectum*)	43.16	11	5.5	4
Prickly sow-thistle (*Sonchus asper*)	.53	1	1	1
Unidentified green leaf fragments	24.21			4
Common red ant (*Formica rufa*)	6.84	1	1	1
Unidentified insects	Trace			1
Total	100.00			
Gravel (figure for gravel represents percentage of *total* stomach contents)	44.0	61	3.8	4
b. Age 6-7 days (5 specimens)				
Bur clover, (*Medicago hispida;* seeds only)	1.53	7	2.6	3
Hill lotus or supinnate lotus (*Lotus humistratus*, or *subpinnatus*)	.83	8	8	1
Alfalfa (*Medicago sativa*; leaves only)	1.65			1
Italian or Australian rye grass (*Lolium multiflorum*)	50.02	129	60.6	5
Canary grass (*Phalaris* sp.)	3.39	33	33	1
Common wild geranium (*Geranium dissectum*)	1.36	8	4.5	2
Napa thistle (*Centaurea melitensis*)	.25	2	2	1
Chile tarweed (*Madia sativa*)	1.32	21	11	2
Prickly sow-thistle (*Sonchus asper*)	.66	14	7	3
Milk thistle (*Silybum marianum*)	.99	1	1	1
California buttercup (*Ranunculus californicus*)	.37	1	1	2
Thimble-berry (*Rubus parviflorus*)	.41	2	2	1
Pimpernel or poor man's weather glass (*Anagallis arvensis*)	.04	2	2	1
Miner's lettuce (*Montia perfoliata*)	.08	1	1	1

b. Age 6-7 days (5 specimens)—Continued

Convallariaceae (?)	2.60	20	20	1
Unidentified green leaf fragments	Trace			2
Common red ant (*Formica rufa*)	6.68	2	1.3	3
Shield bug (Scutelleridae)	9.21	2	2	1
Stink bug (Pentatomidae)	4.13	1	1	1
Corizid bug (Corizidae)	1.36	2	2	1
False chinch bug (*Nysius* sp.)	1.36	4	4	1
Big-eyed bug (*Geocoris* sp.)	.33	1	1	2
Grasshopper (Locustidae)	8.25	4	4	1
Leafhoppers (Cicadellidae—adults and nymphs)	2.85	22	13	3
Unidentified insects	Trace			2
Lynx-spider (*Oxyopes salticus*)	.33	1	1	1
Total	100.00			
Barbules	Trace			2
Gravel (figure for gravel represents percentage of *total* stomach contents)	15.37	.96	71	5

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1.0; *Agoseris* sp., 1.0; *Trifolium* sp., .9; *Microseris douglasii*, .7; geranium, .2; *Stellaria media*, .2; *Polygonum aviculare*, .1; *Lotus americanus*, .1; *Lactuca scariola*, .1.

Other items of green vegetation not found in the stomachs examined, but observed in the field to be eaten by quail were as follows (an asterisk indicates that the plant is an introduced species):

Sisyrinchium bellum (blossoms); **Avena fatua* (leaves); blue grass (*Poa* sp.); **Lolium perenne* (florets); Bermuda grass (*Cynodon dactylon*); **Anagallis arvensis* (leaves); *Sanicula menziesii* (blossoms); **Rumex crispus* (leaves); *hemp (*Cannabis sativa*); *rape (*Brassica napus;* leaves, blossoms); *scarlet runner bean (*Phascolus multiflorus:* leaves); *sour clover (*Melilotus indica;* leaves); *Agoseris plebia* (leaves); **Picris echiodes* (leaves, blossoms); *Hemizonia congesta* (blossoms); **Anthemis cotula* (leaves).

Vegetable Debris. In the case of the California quail the amount of material which could be classified strictly as debris, exclusive of feather barbules, was infinitesimally small. Some more or less indigestible vegetable fragments were present, but these were taken in as integral parts of certain more desirable food substances, and accordingly they were not segregated as debris but included under the respective food items. Examples of this class of materials are pod fragments of bur clover, carpels of filaree, bracts of grasses, pods and placentae of pimpernel.

Feather Barbules. The barbules of feathers were found in about one-tenth of all stomachs and were doubtless swallowed accidentally during preening. They occurred more or less throughout the year and were not more numerous during the period of molt than at other seasons.

Animal Food. The animal food eaten by adult California quail in the area studied by the writer amounted to only .38 per cent of the total food, but, as Table 2 shows, the inclusion of the stomach contents of small young would materially increase the percentage. Ants comprised 68.4 per cent of the animal food taken by the adult quail, with Hemiptera (13 per cent) and lepidopterous larvae (10.5 per cent) next in amount.

FOOD OF YOUNG

Not only does the food of young quail differ from that of the adults by reason of its higher animal content, but also in that the individual items are of smaller size. Large seeds such as those of *Lupinus, Vicia,* red oats, and the pods of bur clover (see page 190) are seldom or never attempted at this stage, while in the case of certain other foods, for example *Lolium multiflorum,* only the smaller seeds are eaten. The average size of the grit particles taken by the young is also less than in the case of the adults.

Age 2–3 Days. The birds of this age (Table 2) were collected after they had died from overexposure to the heat of the sun, and for this reason their stomachs, although moderately full, may not

indicate the normal ratio between animal and vegetable content. The percentage of insect matter is unexpectedly low (6.84 per cent); the stomachs show that even at this age the consumption of seeds and green vegetble material is large.

Age 6–7 Days. The stomach contents of the birds of this group were unquestionably normal. In addition to the high percentage of animal food (34.5 per cent), a considerable number of seeds was consumed.

GENERAL FEEDING HABITS

Times of Feeding. Examination of the crops and stomachs of California quail collected at various times of the day, together with field observation, showed that the birds normally leave their roosts in the morning with crops, and probably stomachs, empty, and feed fairly steadily for about an hour, or until their crops are about half full. After this initial meal feeding gradually decreases, and reaches a minimum at midday; nevertheless it often proceeds intermittently throughout the whole day up to about 4 p.m., with crops from one-third to one-half full. After about 4 p.m. feeding activities noticeably increase and culminate at dusk in a final period of gorging which lasts for twenty or thirty minutes and fills the crops of the birds until they bulge.

As in the case of various passerine birds studied by Stevenson (1933, p. 155), the stomachs of California quail receive a slow stream of food from the crop throughout the day (and night also), and are rarely empty, no matter what the state of engorgement of the crop.

Stormy Weather. Stormy weather shortens the feeding periods, for at such times the birds often remain in the shelter of a patch of thick brush from early morning until only fifteen or twenty minutes before roosting time, when they furtively emerge from cover in compact little bunches, feeding hurriedly, and with only an undertone of their usual "conversational" clucking and cheeping notes.

Presence of Enemies. If the birds are badly frightened by a Cooper hawk or other enemy shortly before roosting time, they sometimes refuse to venture forth from cover for the evening meal, and are obliged to go to roost with nearly empty stomachs. So great is the urge to feed at this time, however, that the birds usually overcome their fright much more quickly than at other times of the day, and are likely to make a concerted last-minute venture into the open just at dusk, in spite of the presence of the enemy unless the latter is directly within their sight. Possibly it is for this very reason that the Cooper hawk is especially active in the pursuit of quail at dusk.

Hours of Feeding During the Breeding Season. At the time of courtship, the male birds spend a large amount of time driving other males away and strutting before the females, especially during the early morning and late afternoon. This leaves them little time for feeding, so that their stomachs are often nearly or quite empty during the day, and are seldom very full even at dusk. The females, however, still feed in the normal manner.

With the commencement of incubation, the males not only continue to drive away other males but in addition they stand guard, alert and unfed, when their mates leave the nest to secure food; consequently the food intake of the males continues to be intermittent and limited.

At the time of incubation the females also change their feeding habits; they leave the nest for the first time at about 8.30 to 9 in the morning and feed steadily for about twenty minutes. Often upon leaving they stand upon their tip toes and whir their wings rapidly, or stretch out the wing and leg of one side simultaneously, like domestic poultry, thus giving evidence of their relief at having escaped for a few moments from the cramped confinement of the nest. The females indulge in subsequent feedings at irregular intervals of about three hours until about 4.30 to 5.00 in the afternoon, when they return to their nests for the night.

After the hatching of the young the same general schedule continues for several weeks, the female and young venturing out at about 9.30 a.m. after the dews have vanished, and feeding under the watchful protection of the male bird; other feedings occur at irregular intervals until late afternoon. The male bird, on the other hand, is still obliged to obtain his food at odd moments while his family are resting in thick cover, and it is not until the female has retired with her brood for the night that he is able to pick up a somewhat more substantial meal.

As the young grow larger and more independent, and learn to roost above the ground, the time spent by the male in rigid watchfulness lessens, and the feeding hours of the entire family approach the schedule followed during the remainder of the year. As the dew hazard vanishes the first morning feeding occurs earlier, the midday rest period is observed, and the chief meal of the day takes place once more just before roosting time.

Feeding Mannerisms. Scratching. Quail scratch the ground vigorously like domestic fowls when searching for food. This habit is especially useful during the months of late winter and spring when the birds are searching for the tiny succulent sprouts of new vegetation. The writer's field notes afford a description of this reaction, which was observed many times at close range: "June 2, 1932. The bird scratched four times on each occasion, then took one step backward and looked for food in the little depression made by the scratching. The four scratchings were always executed two with one foot and then two with the other, either foot being likely to start first, thus: *right, right, left, left;* or *left, left, right, right.*"

Jumping. Quail secure several kinds of food by jumping, notably the blossoms of the buttercup, yellow sanicle, tarweed and sow thistle. The wings are not used in jumping, but are held pressed against the sides, while the neck is stretched to the utmost. When the buttercups are in bloom it is not uncommon to see the members of an entire covey bobbing upward by two's and three's to reach the food above their heads.

In winter, especially when snow covers the ground and shuts off more accessible supplies, the birds jump vigorously for the flower heads

of tarweed and any other species which still contain seeds at that time of year.

The highest that quail can reach with their bills by jumping is about sixteen inches, and even then they often miss several times in succession the object of their efforts. Since many of the blossoms are above this height, the more lofty plants are thus spared and their seeds preserved; hence it is possible that terrestrial feeders like quail may have contributed to the evolution of the long seed stalks of these and various other native plants.

Distances Traveled for Food. Under normal conditions the distance traveled during the day by quail in search of food is slight. In the early fall, when the annual crop of weed seed is at the height of its abundance, a covey will often spend one or two whole days at the edge of a given patch of brush or woodland. Under such conditions the duration of the birds' stay would be theoretically much longer than this if adequacy of food supply were the only factor determining their whereabouts and if the birds hunted for it systematically.

However, a covey gradually moves about over its territory, partly as a result of harassment by enemies but more because of the innate tendency of the birds to feed a little here and there and continually move on, regardless of the fact that by so doing they may move from a plot of ground where food is abundant into one where it is less so. This instinctive (?) propensity is strikingly illustrated in the case of quail which have discovered a patch of ground covered with bait. In spite of the fact that the birds have only to stand still and eat, they pick up a little here and there, then run a few steps forward and pick up a dozen more seeds, often stopping to scratch the ground vigorously, although such scratching is not only unnecessary under these conditions, but actually scatters the seeds far and wide so that many are lost. Presently, as a result of this aimless feeding, the birds have wandered entirely away from the site of food abundance, in which case they usually do not return, at least not for several hours and often for days.

Although such aimless wandering seldom results in a covey traveling more than a few hundred yards in a day, several days carry it gradually, and erratically, over the whole extent of its territory—which is largely coincidental with its food supply. The distance covered per day is not constant, but is governed by chance and by food conditions. For example, regions with a sparse food supply, such as the semi-desert portions of southern California, require more daily searching than do more favorable regions such as the Santa Cruz Mountains.

When the food supply becomes less abundant during midwinter, the distance covered daily by a covey somewhat increases. However, except in a few places at high altitudes, it is rare for a covey to be forced entirely out of its range because the loss by predators automatically increases before this can happen, so that only as many birds survive as can succeed in maintaining themselves in the territory.

Amount of Food Eaten Daily and Yearly. The weight of food eaten per day was determined by the writer according to the method described by Taber (1928, p. 339). This method involves trapping and weighing the birds just at roosting time, keeping them overnight, and then weighing them again the first thing in the morning. From

TABLE 3

RATIO OF FOOD CONSUMED DAILY TO BODY WEIGHT (GRAMS)—SEPTEMBER—DECEMBER

	Males		Females		Young too small to allow determination of sex
	Adults	Juveniles	Adults	Juveniles	
Evening weight	192.6	169.0	187.7	159.8	105.9
Morning weight	182.1	159.3	176.2	151.7	97.9
Loss during night	10.5	9.7	11.5	8.1	8.0
Estimated weight loss during twenty-four-hour period (=food intake)	22.9	21.1	25.1	17.6	17.4
Ratio of daily food intake to morning body weight (percent)	13.2	14.2	15.4	12 3	19.7

the loss of weight occurring during the night, the daily (24-hour) loss may be calculated, and this loss must of course be balanced by the daily intake. At the time the present experiment was carried on the average period spent on the roost was eleven hours. Many birds exhibited an abnormal retention of food in the crop, no doubt as a result of nervousness induced by confinement; consequently only the records of birds which had empty or practically empty crops on the following morning were used. These records comprise night and morning weighings of 108 birds, as shown in Table 3.

The total weight of food consumed on the average by an adult California quail in one year can be estimated, from the above data, at 8760 grams (19.3 lbs.), or (if calculated upon the basis of the known value of 60 lbs. of alfalfa seed to the bushel) 11310.7 cc. (.321 bushel; 10.2 qts.).

That this method of estimating the daily food consumption of California quail is fairly accurate is indicated by the fact that the figures are close to those obtained by Nice (1910, p. 302), by a different method, for captive bobwhites, considering the relative sizes of the two species, which weigh, on the average, 189.5 and 170 grams respectively.

Food Preferences. Quail studied by the writer evidently exercised a certain degree of preference as to what they ate and were by no means swayed by mere availability. The chosen foods represented plants of various unrelated groups and seemed to have as their chief common characteristic a high energy-producing quality.

Although legumes, grasses and composites were abundant and together made up 62.7 per cent of the food of the birds, such plants were by no means the only potential source of food. On the other hand, the writer was surprised to note that certain very common and apparently eminently suitable species of plants were either absent in the diet or represented by insignificant numbers.

That the scarcity was not due solely to chance, or to the relatively small number of stomachs examined, is indicated by the fact that no record of these plants occurs in the reports of Judd (1905) or McAtee and Beal (1912). Seeds of native plants which were common in the Santa Cruz Mountain area, but which were *not* present in quail stomachs in appreciable quantity, belonged to the following species:

Chlorogalium, *Brodiaea*, *Calochortus* (Liliaceae); *Collinsia*, *Scrophularia*, *Mimulus*, *Castilleia*, *Orthocarpus*, *Cordylanthus* (Scrophulariaceae); *Trichostema*, *Micromeria* (both very strong scented), *Sphacele*, *Stachys*, *Monardella* (Labiatae); *Artemisia*, *Achillea* (Compositae); *Dodecatheon* (Primulaceae); *Galium* (Rubiaceae); *Godetia*, *Boisduvalia*, *Epilobium* (Onagraceae).

Not only are the seeds of these plants abundant,but they are also within the size limits to which quail are adapted. It will be noted that the species listed are grouped within a certain few families, and it may be significant that, with the exception of the Compositae, none of these families is represented in the list of foods (Table 1) which are regularly eaten by quail. Furthermore, the two members of the Compositae which are not eaten are notably strong scented.

The characteristic strong scent of the Labiatae (mints) may account for their rejection, but why the Liliaceae, Scrophulariaceae,

and certain others should be refused as food is not clear. Possibly some of them produce a toxic effect when eaten.

Rejection by Quail of Suitable Foods to Which They Are Unaccustomed. A factor which operates in the case of certain other plant foods which are rejected by quail is that of novelty, especially if combined with rather large size. The following excerpts from the field notes of the writer illustrate this:

"May 15, 1932. The quail inside the large inclosure have difficulty in eating barley, with which they are unfamiliar. Only about once out of every six tries, are they successful in swallowing it. It is as if they couldn't get it down their throats, for the kernels actually disappear for a moment at the back of the mouth only to fly out again, as though by the action of the tongue. The birds pick up the barley with evident eagerness but the swallowing is not so easy."

Three days later they had begun to learn to eat barley, but now they refused hemp, which was another food strange to them:

"The birds ate a little hemp, but not much. Although hungry, they would continually walk right over ground where it lay thickly, ignoring it entirely and searching for other more familiar tidbits, and for scraps of green vegetation. I remarked, however, that several of the birds took quite a lot of the remaining barley, picking up six or seven kernels consecutively without dropping any. Evidently they are learning to accept this new food."

It is significant that a certain covey of quail three miles away was accustomed to feed every evening upon barley from a newly sown field in their territory, the crops of these birds becoming enormously distended with the kernels.

Sunflower seeds, red oats and large kernels of corn were consistently rejected by the birds within the inclosure, even though they were brought to the verge of starvation in an attempt to make them eat these foods. On the other hand, small pieces of cracked corn were eaten fairly readily, and certain wild individuals were known to have eaten red oats (see Table 1); however, no sunflower seeds were ever found in the digestive tracts of quail.

Certain native fruits which are larger than sunflower seeds or corn kernels, but which are nevertheless eaten by quail to an appreciable extent, are the hard fleshy fruits of the poison oak and the large dry berries of the madroño.

That large size and not novelty alone may sometimes be the factor responsible for the rejection of unaccustomed foods is indicated by the fact that certain *moderate* sized or small seeds such as kafir corn (*Andropogon sorghum*) and millet (*Panicum* sp.) were accepted at once by both penned and wild quail, in spite of being entirely new to their experience.

Other new foods, however, were refused, in spite of their being of suitable size. The seeds of Spanish and Scotch brooms, and those of Fuller's teasel were consistently rejected by the quail hatched inside the large pen, even when these birds were in a starving condition. Nevertheless, the quail that lived just outside the pen, where these plants were common, ate the seeds in considerable numbers. Stoddard (1932, p. 125) found that as much as three years might elapse before

the bobwhite learned to accept a new food. That California quail finally learn to eat the useful new species, however, is shown by the important place now held in the diet by numerous introduced weeds and forage plants, notably bur clover.

Upper Limit of Size of Food. In the region where the present study was conducted, the largest food items found in quail stomachs were as follows:

Species	Average volume of seed or insect (cc.)	Percent of yearly diet
Oak gall	1/8	.01
Toyon berry	1/8	.64
Pentatomid (bug)	1/10	.11
Convolvulus sp. seed (morning glory)	1/14	.04
Barley	1/15	13.43
Locustidae (one-third grown grasshopper)	1/20	.03
Red oat	1/26	.81
Lupinus variicolor	1/27	2.56
Poison oak	1/31	1.32

Although Stoddard (*op. cit.*, p. 147) reports that acorns constituted more than 6 per cent of the yearly food of the bobwhite in the southeastern United States, and that one bird had eaten fourteen whole acorns together with fragments of several others, the usual food of the California quail does not include such large items, and the results of the present study support the statement of McAtee and Beal (1912, p. 11) that whereas in some cases "a few bits of acorn and perhaps nuts were eaten. . . . the quantity is insignificant."

Lower Limit of Size of Food. In general, seeds less than 1.2 mm. in diameter, such as *Anagallis arvensis*, were not picked up singly, and probably are either too small to attract the attention of the birds readily, or represent too small a reward for the amount of energy involved in picking them up. Many of the seeds which commonly occur in the stomachs of quail are much smaller than this, but seeds of this sort are eaten while still enclosed in their relatively large pods, capsules, or flower heads, and consequently are secured in large numbers with each mouthful.

GRIT REQUIREMENTS

Daily Intake and Loss. The number of gravel particles in 102 stomachs varied from 2296 to 10, the average being 508 (14.26 per cent of total stomach contents). The daily loss of grits through the intestine can be gauged to some extent by the daily intake of fresh particles which are found in the crop. Out of a total of 93 crops, mostly collected in the late afternoon or evening, 47 contained no grits, while the average for all crops was 5.19; the highest number for a single crop was 163. Since the food content of a quail crop collected at the end of the day represents roughly one-half of the total food intake for the day, multiplying 5.19, the average number of gravels per crop, by 2 gives 10.38, which is probably a fair approximation of the daily loss of grits.

The California quail consumes a much smaller amount of grit when hard seeds, such as those of poison oak, form a large proportion of the food. On the other hand, as Table 1 shows, the maximum consumption of grit occurred in late winter and in spring, when seeds of all kinds were scarce and the principal food was green leaf material.

Kinds and Sizes of Grits Eaten. The grit content of stomachs taken from both the Santa Cruz Mountain area and the foothills of southern Napa County was similar in being made up of small translucent quartz particles. The particles were irregular in shape, and varied in adults from about .15 mm. to 5.7 mm. in diameter, the average being 1.2 mm. Particles swallowed by two- or three-day old chicks averaged only about 91.6 per cent as large.

The very minute grit particles which occur in considerable numbers are probably not picked up individually by the quail, nor are they chipped from larger fragments during digestion, since they are also to be found in the crops. Undoubtedly such particles are swallowed accidentally as they adhere to seeds, vegetation, or to other larger pieces of grit. The propensity of quail to pick at nearby objects while wallowing in their dust baths, and the activities of the birds in preening their dust-laden feathers, explain the presence of these microscopic fragments.

WATER REQUIREMENTS

Water Requirements During the Rainy Season. Field records, supplemented by intensive daily observation of 6 adult quail and their 36 offspring reared within the large inclosure during two successive years, have proven that after the appearance of the first autumn rains the birds no longer visit the water holes. The moisture which they require is then derived from the succulent green vegetation which carpets the entire country during the rainy season.

Water Requirements During the Dry Season, Including the Breeding Season. Toward the latter part of April, as the days become warmer, the birds occasionally take a few sips of water in the late afternoon, but drinking does not become habitual until the approach of drought conditions in late June. With the appearance of the young in July, however, a marked increase in the use of water is apparent. Often the adults lead their charges to the water holes three or four times a day, usually taking from three to twenty sips themselves on these occasions.

With the advent of cooler weather in September, the consumption of water lessens, and if the sky remains overcast during a large part of the day, or if there has been a heavy dew the night before, no visits are made to the water holes. At this time of the year two or three days may go by without the birds drinking any free water, and with the coming of the rains once more total abstinence follows.

Previous Opinions as to Water Requirements. There has been some discussion among authorities as to whether the quail of the arid southwestern states must have water to drink. Grinnell (1927) observed that nests of the California quail were rarely or never located more than 400 yards from water. He assumed from this circumstance

that the newly hatched young required water within a few hours after hatching, and that 400 yards was the maximum that such little quail could travel for it. From this he concluded that the water factor was a critical one during this season in the southwestern states for game birds in general.

Vorhies (1928) brought forward evidence indicating that in Arizona at least the Gambel quail (*Lophortyx gambelii*) was not dependent upon water during the breeding season, often nesting several miles from water without ever visiting it, and receiving a sufficient supply from succulent vegetation to satisfy its requirements. Gorsuch (1931, p. 257) records finding the newly hatched young of the Gambel quail as far as ten miles from water.

Experiment on Water Requirements. In order to settle the question as regards the California quail, the writer shut off the water supply in the large inclosure on February 1, 1933, and left the two pairs of resident birds without any source of free water until February 1, 1934. As was expected, the birds gave not the slightest evidence of thirst during the winter and spring months.

With the advent of the summer heat and its accompanying aridity, the birds began to feed every day upon the succulent leaves of a small experimental patch of alfalfa within the inclosure. Even when the maximum daily temperature reached 102° F. during the first two weeks in June, the quail gave no sign of thirst; however, the alfalfa patch grew steadily thinner as a result of the attacks of the birds. That they remained healthy during this period is indicated by the fact that both pairs produced young during the course of the experiment.

After the hatching of the first brood, the weather remained steadily hot with no dewfall, and the alfalfa patch was entirely eaten up. However by July 20, when it was gone, the young of the first brood were able to fly and they, as well as the adults, now commenced to eat the leaves and floral bracts of a few sunflower plants which had sprung up inside the inclosure. During a large part of each day the birds would perch by two's and three's upon the swaying tops of the sunflowers, flapping vigorously to maintain their balance and often pushing one another off in their eagerness to obtain the green material.

Due to the accidental destruction of a previous nest, the second pair of adults did not bring off their brood of 12 young until July 21. By this date all succulent vegetation near the ground, and even within jumping distance above it, was gone. The newly hatched young of the second brood were of course unable to climb the sunflowers to where the larger quail were foraging at a height of three feet above the ground, and consequently they perished from thirst during the ensuing 10 days, although there was an abundance of dry food (seeds) all about them.

All of the young of the first brood, together with the two pairs of adults, lived through the remainder of the summer and subsequent autumn without a drop of free water; however, before the coming of the rains the birds had obviously become less vigorous. Practically every shred of green vegetation within the inclosure had been eaten. The sunflowers were reduced to bare, headless stalks; every prickly leaf of the numerous milk thistles present was eaten down to the tough

midrib; even the rank Spiny Clotburs (*Xantium spinosum*), whose slightest touch is painful to human skin, were reduced to twisted skeletons.

From this experiment it may be concluded that the California quail, like various other species, requires no drinking water *provided* that there is present either a heavy dewfall, a supply of berries, or succulent vegetation. However, since most of the native range of the California quail is subjected to a protracted dry season during the breeding period (June to August), the amount of succulent vegetation approaches zero at that time. The last traces of edible green vegetation are found at the water holes, and for this reason the birds are largely restricted to the neighborhoods of water holes and streams during the nesting season, as pointed out by Grinnell (*op. cit.*).

The Gambel Quail Nests Under Different Moisture Conditions. The independence of water which Vorhies has demonstrated for the Gambel quail is explainable upon the basis of an earlier breeding season, together with a climate which is different from that of the region inhabited by the California quail. The Gambel quail nests in April, at a time when there is an abundance of succulent vegetation (Vorhies, *op cit.*, p. 450). In addition, the birds are able to use cactus, which furnish "a very important food during the hottest summer season," while their diet also includes a considerable amount of insect material (Gorsuch, 1931, p. 255). Moreover, according to Vorhies and Taylor (1933, p. 494), there are *two* rainy periods in that part of Arizona under consideration by them, one (December to March) immediately preceding the breeding season, and the other (July to September) shortly after it.

GENERAL ECOLOGICAL REQUIREMENTS

The ability of the California quail to exist in a given locality is largely dependent upon the following three major requirements:

1. Food. Quail food is chiefly supplied by herbaceous weeds and grasses; not only must it be present in adequate quantity throughout the year, but it must be close enough to cover that the birds are not afraid to venture forth to secure it. A food supply which is more than about fifty feet from cover is largely unavailable for the birds.

2. Cover. In the ecology of quail the function of chaparral land and other cover is to supply protection against enemies and weather, rather than to supply food. Just as food is unavailable to the birds without cover, so is cover of no use without an adjacent food supply. Consequently the most satisfactory combination of these two essentials is represented by an *interspersion* such as one sees under natural conditions along the edge of woods, at the foot of a chaparral-covered slope, at the margins of grassy valleys, and, under man-made conditions, along weedy fence rows and the sides of roads. The relation between quail abundance and the extent of "edge" environment will be more fully discussed in Part II.

In addition to ground cover for the protection of the birds during the daytime, some sort of roosting cover is also necessary, such as the

dense foliage of the live oak (*Quercus agrifolia*) and California laurel (*Umbellularia californica*), or the thick tangles of poison oak (Fig. 11) and sumac (*Rhus laurina*).

In certain arid portions of the state, notably in western Riverside County, there are very few dense shrubs; there the quail are forced to roost within a few feet of the ground in thin stands of brush. The inadequate protection offered by such scant roosting cover is reflected in an unusually high mortality due to horned owls, and probably ground prowlers as well.

3. Water. In addition to the two prime requirements mentioned above, water in some form is essential.

Topography. The California quail ranges commonly from sea level to 4000 feet, and occasionally up to 8500 feet or even higher (Grinnell, Bryant and Storer, 1918, p. 517). Whether the inability of this species to maintain itself at the higher altitudes, where it is replaced by the Mountain quail (*Oreortyx picta*), is due to a lack of food to which it is adapted (the Mountain quail makes use of mast and berries), or to the rigors of the winter season, is not indicated by any of the present findings.

East-West Distribution; Toleration of Humidity and Aridity. So long as suitable food, cover and water are present the California quail is able to live with equal facility in all regions from the humid coastal belt to the margins of the deserts in eastern California. Although the range of the California quail slightly overlaps that of the Gambel quail along the desert fringes, the California quail is unable to compete with the former species throughout the waterless country lying to the east.

The California quail of the coastal fog belt (*Lophortyx californica brunnescens*) is somewhat darker in tone of color than the "Valley quail" (*Lophortyx californica californica*) which inhabits the more arid remainder of the range of the species, and it is possible that the former is more fog-resistant, although this has not yet been proven.

North-South Distribution; Tolerance of Heat and Cold. The fact that the natural range of the California quail does not extend northward beyond the vicinity of Klamath Lake in southern Oregon is probably due to the inability of the birds to find food when deep snow covers the ground for long periods. Even in parts of California the advent of unusually deep snows is accompanied by a heavy quail mortality. In this respect the species is evidently inferior to the bob-white of the northern United States, although even this latter species is by no means immune to the effects of deep snows.

California quail become noticeably sluggish in cold weather, particularly if there is snow on the ground. The writer's field notes afford an illustration:

"January 13, 1932. There is about three inches of snow on the ground and it is cloudy and cold. I saw several quail as they walked out of the brush onto the road. They moved more slowly than usual, with an appearance of sluggishness which was enhanced by their puffing out their feathers and drawing in their heads to an unusual

degree. Three or four of them stood still on the road in a listless fashion, only moving away when I had approached to within 50 feet."

Even in rainy, cold weather, with no snow, this same sluggishness is apparent. For example:

"January 25, 1933. A cold, sleety rain falling. This group of quail was doing what I have several times seen quail do at roosting time, namely traversing open, unprotected places on foot on their way to some distant feeding spot. These birds were about 50 feet from cover; some were standing still, with feathers fluffed out and heads hunched in. A Cooper hawk ought to have been able to pick one up quite easily. I have seen these hawks hunting quail at just this time of day (early dusk), too."

Southward the range of the California quail extends 1530-odd miles without a break, from Klamath Lake through a wide gamut of climatic conditions to Cape San Lucas at the southernmost tip of Lower California.

Wide Range Results from Great Adaptability as to Food and Cover Requirements. From an ecological point of view the California quail may be regarded as a highly successful species because of its ability to maintain itself in regions which differ widely with respect to (1) plant species available as food and cover, (2) seasonal rainfall, and (3) temperature range. It is evident that minor details are unimportant so long as the environment conforms to a general type, the specifications of which are:

1. Good interspersion of cover plants (usually of chaparral type, plus trees for roosting) with food-bearing plants (herbaceous weeds and grasses); and
2. Some available form of water.

EFFECT OF HUMAN ACTIVITIES UPON QUAIL

HUNTING

The Problem. The prominent part which hunting has played in the decrease of quail is unquestioned. The history of the restrictive legislation of the last fifty years amounts to a recognition of this fact, and the early records (Grinnell, Bryant and Storer, *op. cit.*, p. 534; Welch, 1928, p. 123) of enormous annual kills made by market hunters furnish additional evidence. In spite of the increasing number of restrictions on hunting, including the now common practice of posting private lands, quail populations have been kept at a low point throughout most of the state by the increase in the number of hunters, the steady improvement in shooting equipment, the nearly universal use of the automobile, and the constant extension of roads into regions which were formerly inaccessible. How to maintain a constant supply of quail under such adverse conditions constitutes the problem.

The Solution. The only solution for the problem of over-hunting, aside from eventual complete cessation of the sport, is a system of game management directed toward the conservation and utilization of the maximum number of birds which the land is able to produce, together with efforts to increase the productivity of the land itself. How this can be done economically is outlined in Part II.

It would be wrong to imply that hunting is the sole factor responsible for the present relative scarcity of quail. Actually, it is only one of five major causes of the decrease of the birds, and in many localities it is over-shadowed in importance by one or more of these other factors, as indicated below.

AGRICULTURAL PRACTICES

Replacement of Forest, Chaparral and Grass Lands by Cultivated Crops. Whether a given region has been affected favorably or unfavorably, from the standpoint of quail, by the substitution of cultivated crops for the native vegetation depends upon the original character of the vegetation. If the region in question was originally composed of unbroken forest, brush or grass land, with very little "edge" land, the breaking up of such dominant vegetational types into scattered farm units will increase the total extent of "edge" environment, and benefit the quail accordingly. This happened during the early days of the settlement of forest land in Humboldt County.

In the case of chaparral lands, which occupy a large part of central and southern California, it is by no means certain that quail have been benefited by the change to agricultural crops, even where primitive farming methods prevail. Under prehistoric conditions the original chaparral was apparently rather open in nature due to frequent local fires (Jepson, 1925, p. 6; Storer, 1932, p. 323), some being caused by lightning and others being purposely started by the Indians. This open chaparral permitted a plentiful interspersion of grasses and herbaceous weeds, thus resulting in extensive tracts of the "edge" type of environment required by quail. The fact that quail were "excessively abundant" in the early days in regions quite unchanged by man (Fisher, 1893, p. 28) supports this idea. On the other hand, the substitution, under the modern "one crop" system, of unbroken fields of grain and coverless pasture, orchard and vineyard lands for the native chaparral has been markedly unfavorable to quail.

Some orange groves may constitute a partial exception to this rule because they furnish excellent roosting cover; however, because of the cultivation methods employed, quail food is usually absent within them; moreover, they can be considered truly beneficial only where they have not supplanted native trees or chaparral. Eucalyptus trees sometimes furnish suitable roosting cover, as do certain other non-native species.

A certain benefit has also come to quail as a result of the introduction by man of various weeds and forage plants of high food value (see Table 1 and page 177). Plowing, harrowing and related activities are also beneficial, if not carried on so as to destroy necessary cover, because they break up the hardened soil, thereby greatly stimulating the growth of weeds furnishing quail food.

Primitive Farming versus Clean Farming. Although the California quail was formerly plentiful in regions where the early "primitive" farming methods favored brushy fence rows, weedy corners in fields, and similar "edge" conditions, the species has decreased rapidly in recent times with the advent of the modern practice of "clean" farming because the latter practice has rendered large areas

coverless, foodless and utterly unfit for bird life. The adverse effects of clean farming upon wild life, and other serious disadvantages of this practice are more fully discussed in Part II.

Exclusive Use by Man of Water Sources. The fatal effect upon quail in arid regions, of the exclusive use by man of springs and other water sources is fully discussed in Part II.

Irrigation. Irrigation may benefit quail in some localities not only by supplying drinking water directly, but also by maintaining various succulent forage crops, such as alfalfa, which can be used by the birds in place of free water. However, the total harm done to the birds throughout the state by irrigation methods probably exceeds any local benefits, because the water used for this purpose is usually obtained at the expense of streams, springs, or accumulated subsurface water supplies, with a consequent decrease or complete cessation of lowland stream flow and lowering of the water table—all of which results in curtailment of the water available to quail over vast areas, and sometimes even in a marked change in the type of vegetation.

Grazing. As shown in Part II, overgrazing is one of the most important causes of quail decrease on many range lands, not only because of the resulting direct damage to nesting cover, but also, even more significantly, through the wholesale destruction of quail food by the competing live stock.

Another unfavorable result of grazing, which if not already acting upon quail and other wild life at least represents a threat, is the depletion of the mineral supply of upland regions. Thousands of tons of mineral substances are removed from the soil by forage plants each year and are then appropriated by live stock for bone formation and other physiological processes. Instead of being returned to the soil by the death and decay of these grazing animals, however, such materials are permanently removed from the regions from which they were obtained when the live stock is shipped to the markets.

A similar process of mineral depletion also takes place through the removal of cereal and field crops.

This removal of mineral substances has been going on for about sixty years, and evidence is already at hand that cattle on certain California ranges may be suffering from a mineral deficiency during parts of the year, with a consequent lowering of the reproduction rate (Hart and Guilbert, 1928, pp. 25, 29, 31). Storer (*op cit.*, p. 324) thinks that in parts of California the reproduction rate of deer may also be suffering from a low mineral intake, and, if this is true, it seems probable that quail may eventually be affected as well.

Predator Control. In most cases predator control as practiced by private individuals has resulted in far more harm to quail than good because of the popular failure to distinguish between harmful and beneficial predators. For example, such "control" has brought about little or no reduction in the numbers of Cooper hawks, which are important enemies of quail, while it has caused the decrease of red-tails and similar slow-flying hawks, which really are allies of the quail because such hawks feed upon the rodent competitors of the quail.

Predator control as carried on by government agencies has been directed chiefly against the coyote, mountain lion and bobcat, none of which is an important enemy of quail. On the other hand, coyotes and bobcats aid in checking the rodent competitors of the birds and to this extent should be regarded as beneficial.

Rodent Control. Rodent control, particularly as regards ground squirrels, has been carried on in California by government agencies upon an enormous scale for many years (Garlough, 1918, p. 786; Jacobsen, 1918, p. 756; 1931, p. 243; Linsdale, 1931, p. 95). Prior to 1928 it may have benefited quail by releasing them from competition with the squirrels for food. However, with the adoption and widespread use of thallium sulphate in 1928 as a squirrel poison, any benefit resulting to the birds by release from competition has been far outweighed by the destructive effects of this type of poison upon the birds themselves (Linsdale, *op cit.*, p. 103; Shaw, 1931, p. 33).

LUMBERING

As previously mentioned, where the clearing of forests has led to the substitution of "edge" types such as slash, chaparral, or primitive farm land, quail have increased in numbers.

ROADWAYS

Linsdale (1929, p. 143) has shown that roadways exert a beneficial influence upon most bird life far in excess, he believes, of the toll exacted by speeding automobiles, because the weed patches and tangles of shrubbery which accompany such roadways afford an abundance of food and shelter, often in regions otherwise unsuitable for birds.

Although the California quail undoubtedly benefits from the presence of roadways in this respect, it is the opinion of the writer that it does so to a lesser extent than do most other roadside inhabiting species. As explained on page 243, this is partly because of the more than ordinary tendency of quail to collide, while in full flight, with the fences which so often border roadsides, and partly because of the reluctance shown by mated pairs during the breeding season to take wing at the approach of an automobile until too late.

Moreover, if we consider the fact that our present highway system permits hunters to reach even the most remote strongholds of the birds, the net effect of roadways upon quail must be regarded as more harmful than beneficial.

FIRE CONTROL

Relation to Dense Cover. As pointed out in Part II, it is probable that a policy of discouraging the burning of brush areas has had an unfavorable influence upon quail in some foothill regions by promoting the growth of dense stands of tall brush to such an extent that food-bearing weeds and grasses have been crowded out.

"PROTECTION"

Laws. Efforts to protect quail by regulatory laws have probably reached their highest development short of a permanent closed season.

Predator Control and Refuge Establishment. Other attempts to encourage the stock of wild quail have been limited largely to the killing of predators and the establishment of refuges. How far the killing of predators has been successful in bringing about an increase of quail has been indicated previously.

The establishment of refuges is the first step in the right direction; however, in the past practically no effort has been made to improve such refuges from the standpoint of quail aside from the prohibition of hunting, while such fundamental problems as clean farming, overgrazing, usurpation of water, and the relations between food supply and cover, have usually been overlooked. It is in the choice, improvement and maintenance of such refuges that a knowledge of game management is of vital importance.

CALLS OF QUAIL

Although the calls of the California quail are decidedly varied, the significance of a given call is rather constant. The difficulty of reproducing in print even a single common note is shown by the wide diversity of versions listed by Grinnell, Bryant and Storer (1918, p. 518) and by McLean (1930, p. 16) for the well-known assembly call. An additional complication is introduced by the fact that many calls sound different according to the distance of the birds from the listener. Due to the large natural inclosure used during the present investigation, the writer was able to make daily observations during two years upon quail which were calling from a distance of from ten to thirty feet away. Even in the present instance, however, where the conditions for the observation and recording of calls were unusually favorable, emphasis is placed more upon the significance of the calls than upon an attempt to make accurate typographical representations. Moreover, there is a decided individual variation among quail as to the tone, emphasis, and manner of utterance of some of the calls.

The Assembly Call. This is the most familiar and most commonly uttered call of the California quail, and may be rendered *cu-cá-cow* (u as in "luck"; a as in "far"). Although the main accent is usually on the middle syllable, it is occasionally placed on the last syllable. Sometimes when the main accent is placed on the last syllable a fairly strong accent is also given to the first syllable, so that the middle syllable receives the least accent of all, which is the reverse of the usual condition. Some male birds, especially during the breeding season when they are more than usually excited, utter several preliminary *cu's* in rapid succession before giving the full call, thus: *cu, cu, cu, cu-cá-cow.* The writer once heard a male bird, which was greatly excited over the presence of a rival male, give voice to a curious combination of the assembly call and the alarm note described below, thus: *cu-cá-pwit, cu-cá-pwit, cu-cá-pwit.*

The assembly call is usually uttered from one to four times in succession, with a pause of at least ten seconds before the next series is given. It is uttered by individuals which are trying to locate other quail, and is especially in evidence after a covey has recovered from its fright at being scattered by an enemy and is trying to reassemble.

There is a strong tendency upon the part of birds within an assembled covey to answer the calls of strayed or scattered individuals, although such birds are not themselves lost. This tendency to answer enables the lost birds to make their way back to the covey, and may have developed as a result of natural selection. It is so strong that unless the weather is stormy or very cold, one can nearly always locate a covey of birds by imitating the assembly call.

During the cold stormy winter months one seldom hears this call, and it is difficult to get a response from any covey; however, even at this period, whenever a day or two of warm sunny weather occurs, the birds commence calling and answering from far and near. By the last week in February, in normal years, the weather has become appreciably warmer and the assembly call may be heard at intervals nearly every day. At this period the instinct to pair is just awakening; males call out to females in ringing tones, and the females answer with similar but somewhat higher pitched, more rapidly delivered notes which are usually recognizably feminine. Calling females in a cage or trap very soon became surrounded by unmated males. During the height of the pairing season such excited calls may be heard all day long, and sometimes even after dark when the birds are on their roosts, but with pairing accomplished a comparative quiet reigns because the two members of a pair seldom become separated by more than a few dozen yards and do not have to call loudly to learn of each other's whereabouts.

The assembly call is used by both parents in response to the peeping "lost" calls of any of their young which may have strayed away. It acts like a veritable magnet under such conditions, even causing chicks which are crouching in fear before the observer to rise up and scramble in the direction of the calls. Unless the family group is widely scattered, however, the parents utter the call in very subdued, muffled tones, often omitting the first syllable entirely, which is in keeping with the secretive behavior of the birds at this season.

By the first week of September, when the young are well grown and to a large extent able to take care of themselves, the furtive watchfulness of the parents relaxes; family groups begin to coalesce into fall coveys, and with this new gregariousness the assembly call, so characteristic of the autumn shooting days, once more rings far and wide over the land, until silenced by the coming of the winter storms.

That the assembly call is primarily used to keep the birds in touch with one another is shown by the fact that when they are foraging in grass which is so tall as to hide them completely, they give the call with increased frequency, as they do also on windy days when hearing is more than usually difficult.

The Single "Cow!" of the Breeding Season. This note is similar to the last syllable of the assembly call, but it is louder, is heard only during the period of courtship, and is uttered by the males alone. Field notes made by the writer indicate the origin of the call:

"April 1, 1933. Courting time is indeed here, what with the warm, sultry weather which we have had recently, together with the advanced state of the vegetative season on this (sunny) side of the mountain

range. A male calling *cu-cá-cow* twice omitted the first and last syllables of the series, the result being the *cow!* of the breeding season."

The birds commence to give the *cow!* call at the first streak of dawn, while they are still on their roosts, and keep it up from fifteen minutes to about an hour, after which they descend to the ground to feed. From that time on, the note may be heard intermittently throughout the day, although chiefly during the cool hours of the morning and afternoon. Just at dusk, when the birds are once more upon their roosts, there is a minor outburst of calls, which lasts for about ten minutes, or until darkness has definitely fallen.

The *cow!* note is uttered at regular intervals by the bird as it perches motionless near the top of a tree or bush, or any other site which commands a view, yet is not too dangerously revealing. It is uttered at intervals of from 9 to 127 seconds, the average (of 45 calls) being 19 seconds. Following the explosive *cow!*, the bird regularly utters two or three low, plaintive cheeping notes like "*whew, whew, whew*," but these are only audible if the listener is within fifty feet of the maker of them.

On the cooler eastern slope of the Santa Cruz Mountains the first *cow!* notes of the season were heard between April 15 and May 2 during the three seasons of field observation. On the somewhat warmer western slope the first calls were heard two weeks earlier than this. Within two or three days after the first bird or two commences to call, nearly half of the resident unmated males are in full swing, and by the end of the week the daily chorus has reached its height. Toward the end of May, when many of the birds are paired for the season, calling has diminished; by the middle of June only a few birds still give the note; and by the last week of June it has ceased entirely. On rare occasions one may hear some lone bird commence calling again during the latter part of July, but this lasts only for about a day. Such sporadic calling must emanate from males which have either lost their mates or for some other reason are commencing the reproductive cycle anew.

The number of calling males was never more than a small fraction of the total number of males known to inhabit the region, and it was observed that whereas mated birds never gave the call, unmated birds did so *until* the time when they, too, were successfully mated.

The *cow!* call appears to serve as an announcement of territory and also as notice that the bird is in a condition to pair, as Allen (1934, p. 183) has shown to be the function of drumming in the Ruffed Grouse (*Bonasa umbellus*). The call is also analogous with the "*bobwhite*" call from which the quail of the eastern United States derives its name, and which, as Stoddard (1932, p. 98) has shown "is largely the call of unmated cocks." If a person answers one of these calling males with the regular assembly call, the bird will often travel 200 to 500 yards to the source of the calls, evidently in search of the female which is supposedly answering him.

The writer has been informed by Mr. E. D. Platt, in charge of the State Game Farm at Chino, California, that the *cow!* note is only rarely heard from the breeding pens, but that it is sometimes given by males which are confined by themselves.

The Explosive "Squill!" of Defiance. This note is the most difficult of all to describe and has been likened by McLean (*op. cit.*, p. 16) and Grinnell, Bryant and Storer (1918, p. 519) to an explosive note of the domestic turkey gobbler. To the present writer it sounded like a loud, high-pitched, staccato whistle, given here as *squill!* It is uttered two or three times in rapid succession, and has something of the tone of a tightly stretched steel wire which is struck a sharp blow and instantly muted. The note is uttered by the male alone, is clearly one of defiance to rival males, and is heard only during the period of courtship.

Many times the writer has observed a would-be suitor outside the large inclosure call excitedly *cu-cá-cow!* to a mated female within, to be interrupted immediately by a vehement *squill!, squill!* from her mate. In other cases, where an unmated female showed interest in an outside male, while being assiduously courted by a male within the inclosure, the calling of the outside bird would elicit a perfect frenzy of *squills* from his rival inside, which would then be answered in kind, at which the two males would rush at each other and exchange lusty, if futile, buffets through the wire.

This note is uttered with all the vehement energy at the birds' command and fairly explodes from them as they jerk their heads and necks up to their fullest height, with bills pointed skyward.

The Deep-toned Musical "Wip-Wip" of the Male. This musical throaty note is uttered by the male alone; it appears to be associated with sexual activity and perhaps also with the combat of rival males over possession of a female. It was not heard at any other time. An extract from the writer's field notes will illustrate:

"June 2, 1932. There was a squabble between the two males while they and their respective mates were feeding close together. The blue [refers to color of celluloid leg band] male 'elbowed' the red male out of the way, pushing against him and pecking the back of his head and neck, while giving vent to the same deep musical *wip-wip* which he uttered a few days ago during coition."

The Alarm Note. This is the *plit-plit-plit-plit,* or *pwit-pwit-pwit-pwit* call of frightened quail which is so well known to the hunter. There is considerable variation in the number of *plits* given in a series; the minimum number is usually three, while the maximum is ten or more; usually the second *plit* of the series receives the strongest accent, with subsequent syllables trailing off into a faint undertone. Sometimes, if not greatly startled, a bird will give a few *plits* one at a time. In some cases, if the listener is only a few feet away, the note sounds like *whit-whit-whit, wit-wit-wit, what-what-what,* or *whad-whad-whad,* depending upon the individual bird. It is given by both sexes, and at all times of the year, and usually indicates a sense of danger on the part of the birds but not of extreme fright.

When an enemy approaches the nest or young, the alarm note is uttered by both parents with special vehemence and an almost machine-like regularity, and is kept up as long as the intruder remains within sight or earshot. So regularly can a pair with a nest or young be counted on to give this note that it can be used as a means of taking censuses at this time of year.

Often during the nesting season the *plit-plit* note is uttered by one or both birds, when no danger, either fancied or real, seems to be present, especially when the female leaves the nest for a respite from the duties of incubation. At such times one or both members of the pair will alight in the open and commence preening while still giving utterance to the note. Under these circumstances it gradually subsides as the birds go about the business of feeding and dust bathing.

At roosting time one almost invariably hears this note as the birds clamber about in the dense foliage, settling themselves for the night. At that time is seems to reflect a general state of nervousness or undecidedness rather than any sense of danger; indeed the whole covey will usually become silent abruptly if any noise or movement arouses its alarm.

Young birds which are beginning to acquire adult voices give the call very frequently, often rising into the air and flying for several feet at the same time. This is done, evidently, out of sheer animal exuberance and bears no relation to the presence or absence of danger—as is further testified by the fact that at such times the parents exhibit no alarm, although at other times of the year they are quick to take fright at the *plit-plit* of other quail.

The "Kur-r!" Note Signifying Extreme Fright. If the birds are startled by the unexpected appearance of an enemy, this low, throaty note is uttered with a sudden, excited emphasis and repeated three or four times in rapid succession, sometimes to be immediately followed by a series of *plit-plits* as the birds dash wildly for cover, or duck down out of sight in the tall grass. If the birds are not very close to cover, the cry serves as a signal for all members of the covey to freeze in their tracks, no matter in what position they may be at the time. An example of this is furnished by the field notes of the writer:

"April 26, 1932. * * * The four quail were feeding busily when suddenly the yellow [refers to color of celluloid leg band] male gave a prolonged low clucking *kur-r!*, while he held himself perfectly motionless in a half crouching position. Simultaneously with the first note of this call the three other birds 'froze' in whatever pose they happened to be in, the red female looking back over her shoulder, the red male partly crouched down, and the yellow female with her head turned to the right. For a full five minutes all four birds stood thus. None made a sound save the yellow male, who kept up his low note continuously; sometimes the note was so low that I could barely hear it at fifteen feet [location of blind], although the other three quail were twenty or more feet from the sound. Sometimes I could not hear it at all, but was sure that it was being given because of the continuing slight quiver of the bird's body which had marked each audible note. At last the yellow male commenced to feed, pausing once or twice to turn into a statue again. Gradually the rest also began to feed, the danger, whatever it was, being over."

When the field worker hears this call in the Santa Cruz Mountains he will be correct about 75 per cent of the time in concluding that a Cooper or sharp-shinned hawk is after the birds.

Both sexes give the call, and it is especially in evidence when the young are small, at which time the parents become more than ordinarily timid, fleeing precipitately at the slightest alarm, real or fancied.

The hypersensitiveness to danger on the part of the parents at this time doubtless represents an adaptation which has been developed to instill caution in the inexperienced but highly imitative young.

The Distress Cry. This call may be written *pseu, pseu* (as in "few"). It is uttered loudly and rapidly when the bird is seized, or is about to be seized, by an enemy such as the Cooper hawk, and sometimes also when the bird is being held for banding, particularly in the case of immature birds. Although adult birds do not usually cry out thus if grasped around the body during banding, they nearly always do so, for some reason, if seized by a leg or wing. When other quail hear this note they crouch down and remain silent if they are in a free state; if they are confined in a box or trap, however, they flounder about wildly in an effort to escape. A single young quail uttering this note while being banded will often throw a dozen covered cartons full of banded quail into a pandemonium of scuffling and scrambling.

A similar, though somewhat thinner, note was once uttered by an adult female which was trying to lure the writer away from its young by means of the broken wing ruse.

The Peeping Call of Small Young, and Parental Response. This call may be described as a thin, piping *wee-wee-wee-wee-wee*, delivered in a thin, shrill, anxious tone, with a rising inflection on the last syllables. It is given by the small young as they forage here and there close to the parents and serves as a stimulus to the parents to answer with a low, soft, constantly repeated cluck which prevents the chicks from straying.

When the young become lost they utter their note more loudly, plaintively and insistently, and keep this up until reassured by an answering *cu-cá-cow* from the parents, toward which they immediately scramble.

Clucking Notes of Adults. The low soft cluck uttered by the parents to keep the chicks from straying is more frequently uttered by the male than by the female, for the former is more assiduous in the care and protection of the young.

A very low, rapidly uttered clucking note, hardly audible beyond thirty feet and sounding like *mo-mo-mo-mo,* is commonly uttered by quail at all times of the year, often while feeding together. At times its purpose appears to be to keep the members of the covey or family group in touch with one another, but at other times its significance is not so clear; it often grades imperceptibly into the warning *kur-r!* note.

"Conversational Notes." These are continually uttered in subdued tones by mated pairs, and by birds of a family group or covey, while the birds are feeding peaceably together, and consist of a varied assortment of cheeps and clucks. Their exact significance, if any, has not been determined, but since they are only made by individuals when in close proximity to others of their kind, they are doutbless associated with some feeling of companionship, and possibly serve to keep the members of the group together.

SOCIAL ORGANIZATION

Gregariousness. Like other kinds of quail, California quail are strongly gregarious and, with the exception of a few unmated birds during the breeding season, spend their entire lives in the company of others of their kind. Many of the actions of individual members of the family group or covey are coöperative, even though they may be largely instinctive and unreasoned. The coöperative nature of quail behavior is well shown by many of the calls previously described, which would be meaningless if the birds were solitary in habit.

Imitativeness as a Basis for Mass Action. The reactions of each member of a covey are also indicative of a fairly well disciplined social unit. For example, with the exception of a few inexperienced young of the year, when one quail gives the warning *ku-rr!* note and "freezes," they all freeze, and if one bird bursts into the air and sails away from an enemy the others usually follow. That this disciplined obedience has its beginning in the strong tendency of young birds to imitate their parents, which in turn are more than usually furtive and wary during the very time that the young are growing up, has been pointed out previously. The fact that late winter coveys tend to be more alert and disciplined in their reactions to danger is explainable partly on the ground of gradual learning by the young, and also partly from the fact that the more sluggish and least coöperative tend to be weeded out by enemies.

Birds which have become separated from their fellows, and individuals which have been liberated alone in new localities, show marked uneasiness and run about distractedly, giving the assembly call in loud, far-carrying tones. The anxiety of a flock to reassemble at roosting time is so great that it will often do so even in the face of a danger which still threatens.

The imitative tendency asserts itself throughout life, as is shown by the manner in which the adult birds will follow one another as they move from place to place when feeding; inside the large inclosure it was common to observe that if one pair of birds left off dozing and resting in the thick brush and came out to feed, another pair immediately would follow the first pair to the feeding grounds. On the other hand, whatever may be the nature of "thought transference" in certain kinds of birds which form highly compact social groups, the members of which appear to act in complete unison (Selous, 1931), in quail such direct thought transference is slightly or not at all developed; quail follow one another only as they see or hear what the others are doing, and even then their reaction time is sometimes slow, as the following field notes show:

"October 15, 1932. At 5.47 p.m. one of the birds crouched for an instant and then launched into the air toward the roosting tree. At 5.48 the remainder of the flock, except one, sprang into the air and followed the first bird. They did not start *exactly* all at once, for I noticed a slight delay in the taking off of one or two of the birds. One bird remained behind, standing motionless where the rest had been. Half a minute later he, too, left for the roosting tree."

Among adult quail, leadership seems to be determined by chance, with neither sex preponderating. Of course when the group consists of parents and their small young the parents are the acknowledged leaders. Like the bush-tits, described by Miller (1921, p. 125), one or more "leaders" may move off nearly simultaneously in different directions, in which case it is merely a matter of chance, together with the degree of proximity of the potential followers, as to which direction the main body of the flock may take. Occasionally the covey may be temporarily, or even more or less permanently, split through the following of more than one leader.

If any one of the "leaders" is not soon followed by others, it abandons its exploring, even though it may have discovered an exceptionally good food supply, and hurries back to rejoin the main covey. Unlike bush-tits, however, such loiterers, except in the case of very small young, rarely become lost, perhaps because of the relatively slower method of progress of quail and the greater carrying power of their calls.

Coöperative Action. Some of the social habits of quail are decidedly coöperative, one might almost say altruistic. Thus when one bird finds an unusually good supply of food it often calls the rest to it, for example:

"May 8, 1932. All at once the blue [refers to color of celluloid leg band] male discovered a concentrated area of millet seed, and gave a low rapid clucking while he scratched and fed. It was just the reaction one sees in a domestic hen which has found something good to eat and is calling her chicks to come and get some. The blue female, two feet distant, came running to his side and began picking up the grains. The red male, which was ten feet away, ran in a beeline to where the blue male was feeding, and all three fed side by side for nearly five minutes."

One bird will also warn the others of danger, thus:

"October 20, 1932. At 3.35 p.m. I went hunting for the covey at McLellan's and soon located them; however, at my coming they flew in scattered detachments up into the live oak trees. Here it was impossible to see any of the birds, even though I was within sixty feet of some of them. For one and one-quarter hours I stood stock still on the steep, leaf-strewn canyon side, beneath the rapidly darkening canopy of trees, waiting for the birds to "unfreeze." I used my quail caller frequently and would often get a response from some birds in the farther trees; however, one particular bird which was nearer to me and which evidently saw me plainly, kept giving a low but far-carrying *mo-mo-mo* whenever the other birds began to answer me, at which they would become silent and remain so for five or ten minutes thereafter. Night fell without my getting a shot."

Sentry Duty. One of the most striking and highly evolved of the social habits of the California quail is that of the sentry duty that is regularly performed by the males during the breeding season and for several months thereafter (Fig 5).

Prior to the development of this habit both birds of the pair regularly feed together; however, the male gradually tends more and more to cease feeding after a few minutes and stand motionless and alert,

ready to give warning to his mate, of any danger that threatens. At such times the female feeds busily, and contrary to the custom at other seasons, spends little or no time looking around for possible danger. If all is well, the male utters at short intervals a low, soft cluck; in case of danger he utters the *kur-r!* note and *plit-plits* loudly, whereupon the female vanishes.

During the incubation period the male still accompanies the female to the feeding grounds, often flying to meet her as she leaves the nest;

FIG. 5. Male California Quail doing "sentry duty" while his mate and young (hidden in the grass below) forage without the necessity of keeping a lookout for danger.

but now, except for an occasional disinterested peek at some object, he spends the entire time doing sentry duty until the female is ready to return to the nest. What nourishment he gets is picked up at odd moments during the day, especially just before roosting time, since the female returns to the nest some little time before the coolness of dusk has settled.

At hatching time the duties of the male as guardian are enormously increased, for he must now maintain a constant vigilance in behalf of the young birds while they forage throughout the long summer day. Food is eaten by him only intermittently, and he loses weight accordingly. At the least sign of alarm he gives the sharp, warning *kur-r!* note which sends the family scurrying for shelter; and when the coast seems clear, it is he who unobtrusively creeps out of cover before the others and remains motionless for many minutes, on the lookout for any return of danger. If he commences again to utter at intervals his soft clucking note, the others venture out; otherwise they do not.

After the young have grown to nearly adult size and have attained a measure of alertness to danger, the impulse of the male to do sentry duty gradually wanes. Some time elapses, however, before the impulse completely disappears, and the writer has observed it in force as late as December 3, although this was exceptional. By the last week of July (in the Santa Cruz Mountains) the family groups have begun to combine into larger units, with the result that there are usually several males available for sentry duty, which relieves any one of them from full-time responsibility in the matter.

Williams (1903, p. 146) has reported that a given sentry is relieved of his duty after a few minutes by some other male, and that a rough system of rotation is practiced as the feeding flock moves slowly along. The writer has not had an opportunity personally to observe this rotation system, but, in view of the demonstrably limited mental capacity of the birds (page 233), it seems likely that any appearance of system must be due to chance. It must be conceded, however, that one seldom, if ever, observes more than *one* sentry at a time on duty, which indicates that the remaining birds feel a sense of security and a freedom from any necessity personally to watch for danger so long as another of their number is doing so. On the other hand, the bird which is acting as sentry often jumps down into the tall grass and mingles with the rest without being replaced, which is a further indication of the haphazard nature of the system, if such it can be called.

COVEY FORMATION AND RANGE

Method of Investigation. The size, permanency, interrelationships and range of coveys was studied in part by daily field observations and mapping of the locations of birds, but chiefly by means of an intensive banding campaign involving the frequent recapture of every living quail inhabiting a selected portion of quail range. The area chosen for this work comprised about 60 acres (Fig. 13), and since it was almost entirely surrounded by natural boundaries, the frequent capture of every resident bird proved possible.

Eight traps, located at strategic positions in the territory, were operated practically continuously for a year, effecting a total of 1042 captures representing 239 individual birds. Previous to this concentrated drive, 41 additional birds had been trapped 65 times, but these earlier records, although used for other purposes, have not been included in the present calculations.

In addition to being banded with Biological Survey bands, the birds were marked with colored celluloid bands used in various combinations so that individual birds could be recognized in the field by means of binoculars without having to be trapped. Although occasionally productive of worthwhile information, in actual practice the method of marking with celluloid bands proved less useful than was anticipated. Not only did the density of the cover combine with the wariness of the birds and the quickness of their motions to make observation of band colors difficult, but in addition the celluloid proved too pliable, so that many of the birds soon lost one or more bands while running about or scratching for food.

Covey Formation. The first stage in covey formation is initiated at the hatching of the young, at which time they and their parents constitute a compact social unit. This unit endures until the young have acquired their juvenal plumage and are from one-third to one-half grown, or much longer if the family remains isolated. About the last week in July, however, neighboring family groups commence to merge, and this process continues through late summer, to the daily accompaniment of the assembly call, until by the middle of September the full-sized coveys have been formed. At all times, even when first hatched, the young will follow any adults which they may happen to find, regardless of blood relationship.

Size. Since the average number of young in a successful brood is about nine (page 235), five or six such family groups will constitute an early fall covey of the size usually encountered in the Santa Cruz Mountains. In addition to the parents which have successfully reared their young, such coveys usually also include two or three unsuccessful adult birds.

As the season advances and the covey is harassed by natural enemies, notably Cooper hawks, or by man, it gradually shrinks in size unless reinforced by birds from other remnant coveys. In the Santa Cruz Mountains, coveys which have been reduced to less than ten birds usually join with neighboring groups, even if this means partial abandonment of their original territory, and this tendency results in the maintenance of a fairly uniform size in many coveys, even though the *total number* of coveys is gradually decreasing. In December, 1933, the average size of four more or less distinct coveys was 34.75 birds, which is perhaps smaller than in the days of quail abundance thirty to fifty years ago.

On the other hand, there may simply have been *more* coveys in the early days; indeed, it is the opinion of the writer that the very nature of covey organization is such that the permanent coherence of large groups is impossible. Since, as previously pointed out, there is no acknowledged leader, the number of potential leaders increases with the size of the covey until a point is reached where it becomes impossible for all the members to follow one bird, which results in splitting.

On the well stocked area chosen by the writer for the banding study, the ranges of the various coveys intersected, and it was when these coveys happened to meet on the edges of overlap that the large coveys were formed. Under such conditions, splitting and recombining occurred repeatedly throughout the season, the groupings being largely

a matter of chance and often resulting in the more or less permanent transference of some individuals from the range of one covey to that of another. The movements are briefly summarized as follows (see Fig. 13)

Covey	Number of Individuals*	Number of captures in territory of another covey				Number of captures in own territory
		Covey No.	Covey No.	Covey No.	Covey No.	
1	82	2–122	3–14	4– 7	5–0	130
2	59	1– 44	3–41	4– 7	5–0	55
3	69	1– 33	2–18	4–12	5–1	166
4	51	1– 2	2–18	3–17	5–3	65
5	25+	1– 2	2– 3	3–11	4–4	4†

* Number of individuals at hatching of young.
† But little trapping was done in the territory of covey No. 5.

Daily Range. The banding study supplemented by field observations showed that, in the Santa Cruz Mountains, the territory covered daily by a flock of quail is often less than 200 feet in diameter, while if food is abundant, or if the weather is stormy so that the birds remain all day in dense cover, the distance traveled in three days may be only 100 feet. Of course the total distance traveled within this territory will be considerably greater than the figures given, due to the irregular, more or less aimless wandering of the birds which involves a considerable retracing of steps.

When food became hard to find during midwinter, the birds were obliged to cover larger areas in order to satisfy their needs.

During the reproductive season the individual pairs have a sharply circumscribed foraging range, due to the inability of the young to travel far, together with the abundance of food, and this explains the paucity of trapping records at this time of the year.

Seasonal Range. Although the daily range of a quail covey is usually small, the total year-round range of many of its individual members may be fairly extensive, in some cases exceeding two miles. This is because during the breeding season, when the covey breaks up, many of the birds scatter widely, invading regions where quail are seldom or never seen at other times of the year; then, with the advent of the fall season, such strayed individuals may join some group which is nearer to their breeding grounds than was the original covey.

Hunting also causes local emigrations of birds from the area of harassment, as was shown during the present study when two outside birds suddenly joined a covey of banded birds following a shooting foray on some neighboring property one-eighth of a mile distant.

With the appearance of great quantities of green vegetation about the first week of May, some coveys have been observed to shift from their winter headquarters (Fig. 6) to areas of particular abundance such as the margins of grassy slopes on the sunny side of a hill; such shifts rarely amount to more than a few hundred yards, however.

Similar small-scale migrations often take place during the latter part of October when the birds temporarily move into the woods to feed upon the fruits of the madroño, snowberry, wild honeysuckle, etc.

Permanency of Coveys. Although certain individuals of a given covey may fail to return in the following autumn, the covey usually receives a sufficient number of new birds, most of which are young of the year, that its size remains fairly constant. In reality the numbers of a covey and its location are governed largely by the available food and shelter rather than by the fortuitous presence of its individual members; and in this respect the covey is analogous to a river, which constantly maintains itself although the individual drops of which it is composed continually pass onward.

FIG. 6. An ideal winter quail range. The brushy slope shown harbored a flock of about 35 quail at all times other than the nesting season. Dominant shrubs are poison oak, of which dense tangles used for roosting are visible in the foreground at left, and *Baccharis pilularis*, represented by the extensive dark areas of brush. Numerous live oaks (lower right hand portion of the slope) and California laurels (conical trees at upper left of slope *below* horizon line) furnished other roosting sites. Food (including newly sown barley) was gleaned from the adjacent field. The birds spent a whole winter on this area of approximately seven acres.

Homing Instinct in Wild and Artificially Propagated Birds. The behavior of quail which have been raised in captivity and then liberated in a strange environment is often abnormal, as is also that of wild quail which have been trapped and subsequently released in a different locality. Even under such conditions the tendency of the birds is to remain where liberated, provided the environmental conditions suit them, so that quail may be said to have only a very slightly developed homing instinct. Of three wild quail trapped in Oakland, California, and released in the Santa Cruz Mountain study area, all remained where released, and raised young; of four wild birds trapped three miles away and on the other side of the ridge from the study area, and released at the study area, two remained, while the other two, which were never seen again, may possibly have died.

In the case of 67 artificially propagated birds, which were released (with 9933 others) by the Division of Fish and Game in suitable localities in southern California, and which were subsequently shot by hunters or otherwise retaken during the ensuing 16

months, the average distance between point of release and point of capture was 2.6 miles; the maximum was 10.5 miles; 17 per cent of the birds remained in the locality where liberated. Some of the birds that traveled the farthest ceased their wanderings only when they reached the outskirts of the nearest town and found themselves in the proximity of farm buildings and other evidences of human occupation with which they had previously been associated all their lives.

COURTSHIP BEHAVIOR

The courtship behavior of quail is exceedingly difficult to observe under ordinary conditions because of the secretive nature of the birds at such times, together with the effective concealment afforded by the dense vegetation. In the case of the present study an unusually favorable opportunity to observe courtship activities was afforded by the large inclosure frequently referred to above. However, even with the aid of the inclosure and adjacent blind, many details in the mating procedure were missed because of the dense cover which, like other features of the interior, had been left in a natural condition.

The dates given here for the various stages of the reproductive cycle are averages of three years' observation in the Santa Cruz Mountain region, at 1700 to 2000 feet altitude. For other regions they will be slightly earlier, or later, according to the climate. Thus in San Diego County the whole cycle occurs about three weeks earlier than in the region under discussion. In Oakland, Berkeley, and Palo Alto, California, whose respective climates are warmer and the vegetational cycles earlier than in the Santa Cruz Mountains (although these cities are all within 50 miles of the mountains in question), the reproductive season commences about seven to ten days earlier.

Pugnacious Stage. About the last week in February, if the weather has not been unusually cold, the first signs of pairing commence to be in evidence. Certain males which have been peaceable enough until now will occasionally lower their heads, with crest feathers laid back, and make little runs at other males in the covey, at which the latter usually dodge away without offering resistance.

With the coming of warm weather, however, as such minor encounters become numerous, the males grow more truculent. The males also give the assembly call with increasing frequence, apparently to attract the females, and these, in turn, can often be heard calling in answer. Unfortunately at this time the birds become more secretive and as they carry on their courtship activities in dense cover, the observer can only obtain brief glimpses of the drama which is being enacted.

Apparently each male tends to attach himself to a particular female which he follows about, while constantly endeavoring to drive away any other male which comes near. The fighting between males occurs almost any time that two males get within two or three feet of each other. At such times one male runs at the other with lowered head and ruffled feathers, but now, instead of running away as formerly,

the other will often stand his ground with lowered head, returning peck for peck amid a chorus of excited clucks and loud *squill!* notes. The birds rush at each other and dodge with great rapidity, sometimes even fighting for a moment breast to breast, when they peck at each other's faces and leap simultaneously into the air like fighting roosters. Quoting from the writer's notes: "Sometimes while thus engaged, one would come down squarely upon the back of the other, which resembled the position taken during coition; perhaps the birds momentarily got their instincts mixed."

This seems significant in the light of Allen's observation (1934, p. 183) that sex as such is not recognized in birds and that a dominant male will attempt to copulate with a bird of the same sex if the latter has been reduced to submission. The writer has also observed a male drive away a female on one occasion, which is similar to the behavior of some of Allen's grouse. Usually, however, one of the contestants turns and bolts before hostilities have become violent, and in any case the fighting never lasts more than a minute.

The vanquished male is not usually chased beyond ten or fifteen feet, but occasionally the pursuit lasts longer as the winner follows every twist and turn of his foe with furious determination. On one rare occasion the loser was actually pursued through the air for fifty feet before the chase was abandoned. Immediately upon the conclusion of a battle the victorious one gives the *squill!* note with great energy and defiance.

In a state of nature, where the vanquished bird has an opportunity to escape, such fights must seldom prove harmful, but if the birds are confined in a trap, one bird will often kill the other by picking the base of the skull and adjoining neck vertebrae clear to the bone.

During this period the covey still preserves its identity but it is now split into discordant groups and torn by the excitements accompanying the gradual development of sexual awareness, so that its final dissolution is imminent. Although the writer was not able to observe the details of the process, it is clear that as a result of several strenuous weeks of fighting and calling, each successful male wins a place by the side of a particular female and prevents all other males from approaching her. As in the case of the bobwhite, female California quail take no part in the scuffling of the males, nor do they fight among themselves, but that they are interested bystanders is indicated by the fact that they frequently give the assembly note in response to that of the males and often come running in answer to the calls of the latter.

Like certain pigeons observed by Whitman (1919, pp. 37, 154), the females seem to exercise some choice regarding their future mates, responding to the attentions of one suitor while ignoring those of another which is equally assiduous in courtship. The writer trapped a female, together with a male which was paying court to her, and released them inside the large inclosure. In spite of the constant attendance of this male, she would have nothing to do with him for several weeks, but spent nearly all of each day answering the calls of various males on the outside, and trying to get out to them. At length his perseverance was rewarded, but only after most of the unmated cocks outside had procured mates and left the vicinity.

In ordinary years it is common to see the birds of a covey feeding or running along the roadsides in pairs by the middle of March; at night the birds still roost together in flocks, the birds of a mated pair probably perched close together, but this is the final stage prior to the breaking up of the covey.

Dissolution of the Covey. Coincident with the pairing of the birds within the covey there develops a strong tendency on the part of the various pairs to stray away in various directions without heed as to the direction taken by others. By the middle or latter part of April, as a result of this tendency the flock has almost entirely vanished as such, and one now encounters single pairs of quail far from the normal range of the covey. Such mated pairs seem to be looking for a nesting site, and in their travels they are often seen in the most unexpected and apparently unsuitable places, such as the scanty shrubbery around public buildings, or along trails in the thick woods.

Behavior of Unmated Males, and Its Relation to the "Cow"! Note. The significance of the *cow!* note as an announcement that the male bird has appropriated territory and is in a condition to mate has been discussed on page 201. The majority of the males in a given area are able to secure mates at the commencement of the courtship period and, like Allen's grouse which did not drum, are not impelled to give this note; instead, they pass into the next phase of the reproductive cycle.

In marked contrast to their furtive, timid habits after the hatching of the young, is the boldness, or, more correctly, obliviousness to danger, shown by the males during the period of courtship. While intent upon reaching a female which they have espied they will often allow an observer to approach them in full view to within forty feet, at which they will merely run forward a few feet and then stop, even though still far from shelter.

The Completion of Mating; Loss of Pugnacity by the Male. After the middle or later part of April, when the fighting and courting is largely over, the two birds of a pair remain closely associated; wherever one goes the other follows, and if they become separated by the harassment of an enemy they call anxiously to one another as soon as the danger has vanished, and quickly find each other again. Neither individual of a given pair has exclusive leadership during their daily travels, but the female seems to strike out the route more often than the male. At the roosting hour the two birds fly up at the same time into the foliage and spend the night close beside each other. If they happen to find themselves separated by a few feet upon arriving, one or the other may be seen to leave its perch and fly over to that of its mate.

The male has now become less noisy and has lost most of his combativeness, only driving other males away when they approach to within five or six feet of his mate or himself, and not always doing so even then. More and more he displays the impulse to stand guard while the female feeds, alert for danger and silent except for a low, soft clucking.

After an undetermined interval following pairing, coition takes place, the delay apparently resulting from the time required by the

female (or perhaps the male) to reach the appropriate stage of the cycle. Readiness to copulate is shown in the male by his walking slowly and somewhat hesitatingly up behind the female as she moves leisurely along feeding, and placing one foot upon her back. If she squats down, with partly extended wings, the act takes place.

Although the thesis that birds do not recognize sex has been demonstrated in a number of cases by Allen (*op. cit.*), and although it has been increasingly in vogue since the publications of Herrick (1910) and Howard (1920, 1929) to interpret the reproductive activities of birds in terms of instincts and blind physiological cycles, this does not mean that birds are without powers of keen discrimination as to the personalities of others of their kind, or that they fail to act consistently toward these personalities, whether with motives of anger or of affection. An example in illustration of this latter idea is furnished by the reactions of two mated pairs of quail within the large inclosure, as observed from a distance of fifteen feet. The reproductive cycles of the blue (refers to leg bands) pair coincided, whereas those of the red pair evidently did not as shown by the fact that the red female refused for about a week to allow her mate to copulate (although they later reared a brood of young). Balked in this direction, the red male tried repeatedly during the week to copulate with the blue female whenever both pairs came out of the brush to feed together at twilight. In every instance observed, the blue female refused to accept his attentions, although she received the advances of her own mate, while the blue male was evidently roused to anger (the word is used after due consideration) by these attempts upon his mate. One instance out of many recorded in the writer's notes may be quoted as an illustration:

"June 2, 1932, 7.16 p.m. . . . Just at this time when the blue male had his back turned on the other three and all of the birds were standing idly about, I saw an act which looked highly intelligent and purposive for a bird. The red male suddenly walked rapidly, and half crouching, in an unequivocally *stealthy* manner (none of his usual hesitation) over to the blue female three and one-half feet away—the blue male remaining oblivious to it all. The red male mounted upon her back, but she, as always, refused to requite his amour. Instead she walked toward her own mate, carrying the would-be adulterer, perched standing, upon her back—a most amazing sight. As the blue female drew near, her mate suddenly caught sight of the two; instantly he charged at the red male, knocked him off his mate's back, pecked him once and then gave him a distinct bite—a hard, determined, savage nip on the back of the neck. The blue female ran away, while the red female, as usual, continued feeding unconcernedly."

NESTING HABITS

Unfortunately the extreme density of the cover, which has been commented upon previously, rendered the location of quail nests more than usually difficult in the region covered by this study.

Four successful nests were available for observation at unknown points inside the large inclosure, but the likelihood that a search for them would result in desertion, or other abnormal behavior on the part of the adults, appeared so strong that no effort was made to locate

them. Several nests were found by accident, and these, together with field observations on the behavior of the adults and the subsequent appearance of the young, have resulted in the accumulation of a certain amount of information. An additional season devoted solely to the study of nesting habits would have yielded highly worthwhile results.

Season of Nesting. In the Santa Cruz Mountains, altitude 1700 to 2000 feet, the earliest date for the completion of a set of eggs was (approximately) April 18; the latest date was June 27; while the average for twenty-one observed instances was about June 9.

Nest Site. Authorities are agreed that California quail are "far from particular" as to the choice of nest sites, which is equivalent to saying that they are highly adaptive. All nests found by the writer were in slight depressions beneath but at the *edge* of clumps of overhanging brush or artificial shrubbery; likewise, the descriptions of nest sites given by other authors indicate that, whatever their diversity, all of the nest sites have as a common characteristic their location in an "edge" type of environment.

The vicinity of Strathmore, Tulare County, is flat valley land, treeless except for cultivated varieties, and is largely devoid of cover other than that provided by grasses and forage crops. The quail have nevertheless been able to invade this region, finding food in the rich farming zone, and nesting sites in the vineyards, where they place their nests against, and, when possible, partially beneath, the straggling trunks of the vines.

Incubation. None of the male California quail within the inclosure was ever observed to incubate the eggs; however, Mr. John B. Price has reported that, on the Stanford University Campus in 1933, when a female quail deserted her nest the male took over the incubation and successfully brought off the young.

The male California quail observed by the writer spent their time dozing, feeding at odd intervals, or doing sentry duty, while the females were on the nests. When the latter left their nests to feed, their mates flew to meet them, and remained on guard over them.

The incubating female first leaves the nest at about 8.30 to 9.00 in the morning, flying to the nearest feeding ground, where she stretches her legs and wings, fluffs out her feathers, and relaxes generally, returning to her duties in about twenty minutes. Other recesses occur at irregular intervals—of about three hours each on bright, warm days—until 4.30 to 5.00 p.m., when she settles upon the nest for the night, leaving the male to feed and do sentry duty until dusk, at which time he flies up to roost alone.

Female California quail, because of their protracted stay upon the nest, have less opportunity to defecate than under ordinary circumstances, with the result that the droppings which they pass during the brief intervals away from the nest are of the large size characteristic at this period.

Number of Broods per Year. No indication of the raising of two broods of young by a given pair of birds was encountered during this study, in spite of the fact that the intensive banding program of 1933 should have revealed such a condition had it existed. Although many

groups containing young of two distinct ages were encountered, calculation of their probable ages showed a difference of less than thirty days, which would be the shortest lapse of time possible between the hatching of the first and second broods (the minimum figure for incubation period given by Grinnell, Bryant and Storer [1918, p. 529], is twenty-three days, plus the time required for deposition of second set).

A few records exist which indicate the possibility of a female producing two broods in one season (McLean, 1930, p. 19), but if this does take place the instances must unquestionably be rare.

CARE OF YOUNG

Brooding. During the first few days after hatching, the female broods the young during most of the time that they are not actively foraging. Whether or not the male also broods was not learned. The female and young retire for the night at about 4.30 to 5.00 o'clock, or as soon as the air becomes cool, which is several hours earlier than is customary for full-grown birds, this early habit representing an adaptation for the protection of the young from the chilling to which they are exceedingly susceptible. For the same reason, the quail family does not stir abroad in the morning until about 9.00 o'clock, or until the sun has thoroughly warmed the grass. On mornings following a heavy dew, the young quail are often brooded until 11.00 o'clock, while on the other hand, if the night has been exceptionally warm and dewless, they may appear as early as 5.00 a.m.

Susceptibility of Young to Chilling. The susceptibility of young quail to fatal chilling, when they are exposed to dampness or even cool air, is so great as to be a matter of common knowledge. An illustration is afforded by an experience of the writer as follows:

"July 5, 1932. I kept the day-old young in a closed carton for about ten minutes before weighing them. It was a hot morning, and thinking that they might become overheated I put a bunch of damp clover stems into the box in the shade.

The result was almost fatal. When I returned, all but one of the youngsters were in a huddle at one corner of the box. The one remaining baby had got its under surface quite soaked, probably as a result of having been pressed against the clover by the others. It was very feeble, and when laid upon its back it had not even enough vitality to turn over. I thought that it would die shortly; however, I placed it in the warm sun (only its head being shaded), and in fifteen minutes it had entirely regained its strength."

Resistance to Wetting. On the other hand, if the weather be dry and warm, young quail easily endure an accidental wetting. Thus, the writer saw a day-old youngster inside the large inclosure instantly paddle out of a pool of water one and one-quarter inches deep into which it had fallen, without being harmed by the experience. Undoubtedly the breeding of quail has become timed, through a process of evolution, to coincide with the driest portion of the year commensurate with the maturing of the young before the rigors of winter set in.

That California quail, at least of the coastal subspecies, are accustomed to withstand the heavy ground fogs which regularly inundate their territory, is self-evident. On the Pacific slope of the mountain crest upon which the present study was carried on, cold dense fogs blanketed the quail country practically every summer night from about 6 p.m. until about 9 a.m. of the following day (Figs. 7-8), yet produced no visible ill effect upon the birds; moreover, this is the very region which not only supports a considerable quail population at the present time but which is described by Welch (1928) as a center of quail abundance in the days of market hunting.

Undoubtedly the ability of the young to survive in this fog belt is due to the fact that they are brooded until after the sun has driven

FIG. 7. Area of quail abundance on humid ocean-facing slope of San Mateo County, showing the blanket of cold fog which inundates this country each night in summer without detriment to young quail, because they are brooded until it disappears at about 9 a.m.

FIG. 8. Same area as above, a few hours after the disappearance of the fog. One of the reasons that this region has always supported a numerous quail population is that a large amount of "edge" land is present. Unfortunately, over-grazing has greatly reduced its value to quail in most places.

away the fog in the morning. From this it will be seen that the activities of an enemy which forced the family to move during the period of dampness would be injurious even if such an enemy failed actually to capture any of the birds. So, too, it would be impossible for quail to breed in a region where the fog did not disappear for a long enough period each day to allow adequate foraging on the part of the young.

Although brooding by the female might also be necessary under certain conditions to protect small young from the intense rays of the sun, such protection is ordinarily supplied by the dense cover into which the family retreats during the midday period. As a matter of

fact the young withstand high temperatures much more readily than low ones.

Feeding. The parents do not feed their young directly, but merely serve as a focal point for the foraging of the baby quail; yet they are markedly solicitous for the welfare of their offspring, especially in the case of the male. If one of the parents discovers some unusually attractive or abundant food supply it gives a low, excited series of soft clucking sounds, like those of domestic chickens under the same conditions, upon which the young come running to the feast.

Relative Solicitude Displayed by the Two Sexes. The greater solicitude of the male is well shown when one surprises a family of small young and their parents. If there is the slightest chance of escaping detection, the male will remain with the young rather than slip away as the female frequently does. An illustration of this is afforded by the writer's notes:

"July 5, 1932. Mention should be made of the extreme tenacity with which the parents (especially the male) held to the dense cover right at my feet while I was catching the baby quail. The cover was dense enough to completely conceal the old quail, and since they still had a few of the uncaught young with them, they were extremely loth to leave. I could walk up to within two and one-half feet of them without knowing they were there, and would only become apprised of their whereabouts when they burst out of the clover with a whir of wings and sailed off, to alight thirty feet away and call *plit-plit-plit* frantically. No wonder I couldn't locate any of the breeding quail up at the pasture recently! . . . As usual the male was more solicitous, or at least more bold. He always returned first, called to the young more frequently, and remained longer."

Defense of Young by Parents. Adult quail are by no means as helpless in the defense of their young as one might suppose. Even large animals are sometimes driven away from the vicinity of a brood, the male usually being the more aggressive, as in other activities pertaining to the care of the young.

The writer saw a male quail chase meadow mice (*Microtus californicus*) away from the vicinity of the brood several times, and has observed the routing of thrashers (*Toxostoma redivivum*) on many occasions; in addition he has received reports from other observers, as follows:

Mr. A. B. McLellan, a rancher living on part of the area covered by the present study, saw a male quail fly at his dog and chase it away from a brood of young. Mr. Donald D. McLean reported another instance of a dog being driven away; also an attack upon a spotted owl (*Strix occidentalis*) which he had flushed, by a male quail, the latter hurtling with considerable force at the owl as it flew by. Mr. McPherson Lough, deputy game warden at Palo Alto, watched a male California quail as it successfully defended a brood of small young from the attacks of a California jay (*Aphelocoma californica*); he also saw a male quail repeatedly rush at a king (?) snake in an open field, but was unable to find any of the young. Mr. Allan McKean, formerly bird and animal economist for the Division of Fish and Game,

reported that a male quail made repeated dashes, on foot, at a road-runner (*Geococcyx californianus*) which was near a brood of young quail until the road-runner was driven away.

There is a published record of a California quail chasing away a jay (Post, 1932, p. 96); while Jaeger (1926, p. 271) records that a *female* quail "in close coöperation" with an English sparrow (*Passer domesticus*) drove a weasel (*Mustela xanthogenys*) across a vacant lot and an adjoining street, until they were frightened by a workman.

Feigning Injury. On one occasion when the writer suddenly came upon a brood of young accompanied by their parents, the female toppled over upon her side, and uttering a thin, peeping distress cry, struggled and fluttered in the dust as though mortally hurt. In the meantime, of course, the chicks scrambled, cheeping, into the dense brush. Although this ruse has been recorded once before, by Proud (in Bendire, 1892, p. 29), it does not seem to be common, for none of the parents of numerous other broods discovered by the writer acted this way.

Timidity of Adults in Relation to Imitativeness of Young. As mentioned previously, the adults are far more timid during the time that the young are small than at any other season, and this doubtless has an adaptive significance. As an example of this hyper-sensitivity to danger, the writer observed many times the seemingly panic-stricken state of parent birds inside the large inclosure, caused by a glimpse of some one walking along a certain, not far distant, path. The birds would cry *kur-r!* and instantly dive into the tall grass, their imitative young scrambling pell mell after them, and all remaining motionless as stones for long minutes thereafter. Yet these same adults, both before and after the breeding season, were accustomed to feed in the open with perfect unconcern while numerous persons passed back and forth along this path.

Limitations of Instinct as Displayed in the Care of Young. That the behavior of adult quail in caring for the young rests upon no more exalted an intellectual level than do the other instinctive activities of birds is well shown by the rather common instances of maladjustment between instinct and need. For example, no direct effort is made by the parents to help their chicks out of difficulties, no matter how simple the required act of deliverance may be. If one or more of the youngsters happen to tumble into a ditch or become caught in thick weeds the adults will remain in the vicinity for a time, lending encouragement by answering with frequent calls of *cŭ-ca-ców* the disconsolate cheepings of their offspring, but that is all. If the youngsters are able to extricate themselves unaided and catch up with the gradually receding family group they are saved; otherwise they are not. It is for this reason that one finds abandoned stragglers fairly often during the summer months.

Of course this rough-and-ready system of culling tends to insure that in the long run only the most nimble and vigorous individuals shall survive. A compensating circumstance is that the adults show no aversion to adopting the lost young of broods other than their own. This readiness to adopt other young explains many if not all of the cases where young of two distinct sizes have been observed following a single pair of adults.

GROWTH AND BEHAVIOR OF THE YOUNG

Since the present investigation was conducted primarily in order to learn the environmental requirements of quail, little time was available for a detailed study of the growth and behavior of the young. For this reason the data presented on this subject are not as complete as desired.

HATCHING

In the Santa Cruz Mountains the first brood of small young was seen on May 11; the latest was seen July 19; while the average date was about July 2.

FIRST FIVE DAYS

Frailty. Some of the characteristics of the behavior of small young have been noted above under previous headings. For the first three or four days after hatching, baby quail are distinctly weak and frail, in spite of the agility which they display when following their parents. During the first day, especially, they repeatedly fall headlong over small obstructions, such as clods and grass stems, and it is evident that their precocious activity is possible chiefly because of the small size of their bodies, which requires relatively slight muscular strength to move. The frailty of the youngsters at this time is also shown by the ease with which they succumb to chilling, as mentioned above.

Initial Fear Reactions. Like the young of other species of birds, newly hatched quail are equipped with only a generalized fear mechanism; they probably give the fear reaction to any large moving object, irrespective of whether it may be harmful or not, and only learn *what* to fear as the result of an extensive period of tutelage under their parents.

When a human intruder approaches a family group, both adults and young usually crouch down in the long grass and remain perfectly still, thus being likely to escape observation. However, if escape by crouching proves impossible, and the adults are forced to leave in the explosive manner previously described, the young instantly scramble in all directions, uttering in chorus their fine cheeping *wee-wee-wee*. When they come in contact with any object such as a clod, clump of weeds, or a dry leaf, into or under which they can squeeze themselves, they become silent and motionless unless actually seized by the enemy. They abandon their crouching tactics only after the frenzied *plit-plit* of the parents has subsided and the low clucking notes and subdued *cú-ca-ców* of parental encouragement are heard. Even when the youngsters have been captured and are huddling silently in a closed carton, they will come to life with loud peeps and frantic scrambling if they hear this call.

The crouching of young quail in crevices when under the stimulus of fear resembles the thigmotactic reactions of young terns under the same stimulus (Watson, 1908, p. 242). Like the latter, the quail chicks are often satisfied to sit quietly with their heads in a cranny, even though their bodies can be seen by the enemy.

Feeding. The instinct to scratch in surface litter and peck at small objects is present from the first, but it is doubtless necessary for quail chicks to learn to distinguish edible from inedible objects by a process of trial and error, as is the case in the domestic chick. The propensity to eat insects must also be instinctive, since it can hardly be learned by imitating the 99.62 per cent vegetarian parents.

Iris. The iris color at this age is light brown instead of dark brown as in the adults.

SIXTH TO FOURTEENTH DAY

By the sixth day the young quail are noticeably stronger and no longer tumble over every little obstacle. They often jump into the air to a height of three or four inches, thereby showing the first signs of the instinct to play. Small clods or other low objects are hurdled or used as lookout stands by the youngsters as they scamper about in response to the urge to exercise their developing muscles.

A slight increase in efficiency of the fear reactions was shown by the youngsters in the large inclosure on this day, in that when actually pursued they ran far into the tall grass, threading their way among the tangled stems, instead of merely crouching down next to the nearest clod. On the other hand, they had as yet acquired little or no sense of *potential* danger, for while feeding they ran here and there around the old birds, cheeping loudly and showing none of the cautious watchfulness of their parents.

FIFTEENTH TO TWENTIETH DAY

By the fifteenth day the young are just learning to use their wings. They run and jump more vigorously than ever, often leaping into the air when there is no obstacle to hurdle, and fluttering along at a height of two and one-half to three feet above ground for a distance of seven or eight feet. When suddenly confronted by danger, they spring into the air and fly toward the nearest cover, and once they have gained it, they can be forced to leave only with difficulty.

During this period their thin peeping note grows stronger and deeper in tone, and in addition the birds now commence to give the *plit-plit* note of the adults. The latter note is as yet decidedly squeaky in tone, as well as being less loud than that of the adults; however, it is recognizable as the same vocal process.

Although the youngsters are thus manifestly more able-bodied, they have as yet learned very little caution from their parents, and are noticeably self-willed. An example from the writer's notes will illustrate:

"July 19, 1932. . . . After they had drunk, the male turned and walked back toward the grass. He clucked several times, but only a few of the chicks followed him, the rest being scattered about in all directions. It is evident that they are becoming more self-willed and independent. I approached so close to the window of the blind that the male saw me. He clucked more emphatically and retreated farther into the grass, but still the chicks paid little heed. A few more came to him, and once, when he clucked a little more insistently, in fact giving the danger call, one of the chicks jumped *away* from him and into a clump of weeds—but it reappeared a moment later

and continued feeding. After several minutes they all gradually joined the parent."

Such laxity in obedience to parental warnings doubtless results in the destruction of many young birds of this age.

TWENTIETH TO FORTY-FIFTH DAY

Between the twentieth and the forty-fifth day the initiative instinct of the youngsters commences to assert itself, and they readily "freeze" at the danger note of the male, although they still show a marked tendency to relax and commence feeding again before their more cautious parents are ready to do so.

During this period the young birds continue to exercise their developing wings, and also their vocal powers. Often at this time several individuals spring into the air at one time with excited, squeaky *plit-plit* notes, and flutter into the nearby cover, as if threatened by danger. Actually no danger exists, and such play activities serve merely as a drill in preparation for future necessity.

At this stage of development the youngsters are in full juvenal plumage, with a sufficient coating of feathers that brooding by the female is no longer necessary. Accordingly, the whole family now roosts together in the trees, retiring at the regular roosting hour observed by the adult birds.

Dust bathing is indulged in by the young from this time forth, and the diet changes gradually from the markedly insectivorous type of previous weeks to the nearly 100 per cent vegetarian fare of the adults.

LATER STAGES

As the birds begin to acquire their first fall plumage, about the eighth week, their flight becomes considerably stronger, taking on the powerful whirring wing motion of the adults. Accordingly, the young birds come to trust more to their wings when escaping enemies, and less to their earlier crouching concealment tactics. Indeed, at this time they flush more readily than the adults, if one beats the cover where they are hiding.

At this stage they have commenced to absorb some of the wariness of the old birds, responding with celerity to the signal to "freeze," and diving quickly into cover when alarmed. However, many of them still have the perilous habit of perching in plain sight on the tops of bushes after having been flushed, and it is doubtless significant that more quail were observed to be captured by Cooper hawks at this season than at any other time of the year. The gregarious habit of quail provides an efficient if somewhat rough and ready school of training from which the young birds continue to learn, even after attaining adult stature.

On the fifty-second day the young quail in the large enclosure were heard giving the assembly call for the first time. The notes were faint and shrill, while the amount and placement of the accent given the various syllables varied greatly, thus: *cú-cú-cú, cú-cú-cú; cu-cu-cú, cu-cu-cú.*

The "conversational" cheeping notes uttered by feeding quail gradually developed from the peeping of the young as their voices became deeper and less shrill; however, the clucking *mo-mo-mo-mo*

note was not heard until the birds inside the inclosure were sixty days of age.

Weight Increase. Young quail grow slowly during the first week after hatching, as the following figures, from one brood, show:

Age (days)	*No. of birds weighed*	*Average weight (grams)*
2	15	6.1
6	10	8.4
20	6	19.3
21	3	27.2
76	4	128.5
77	1	121.3
78	1	128.8
adult	550	189.5

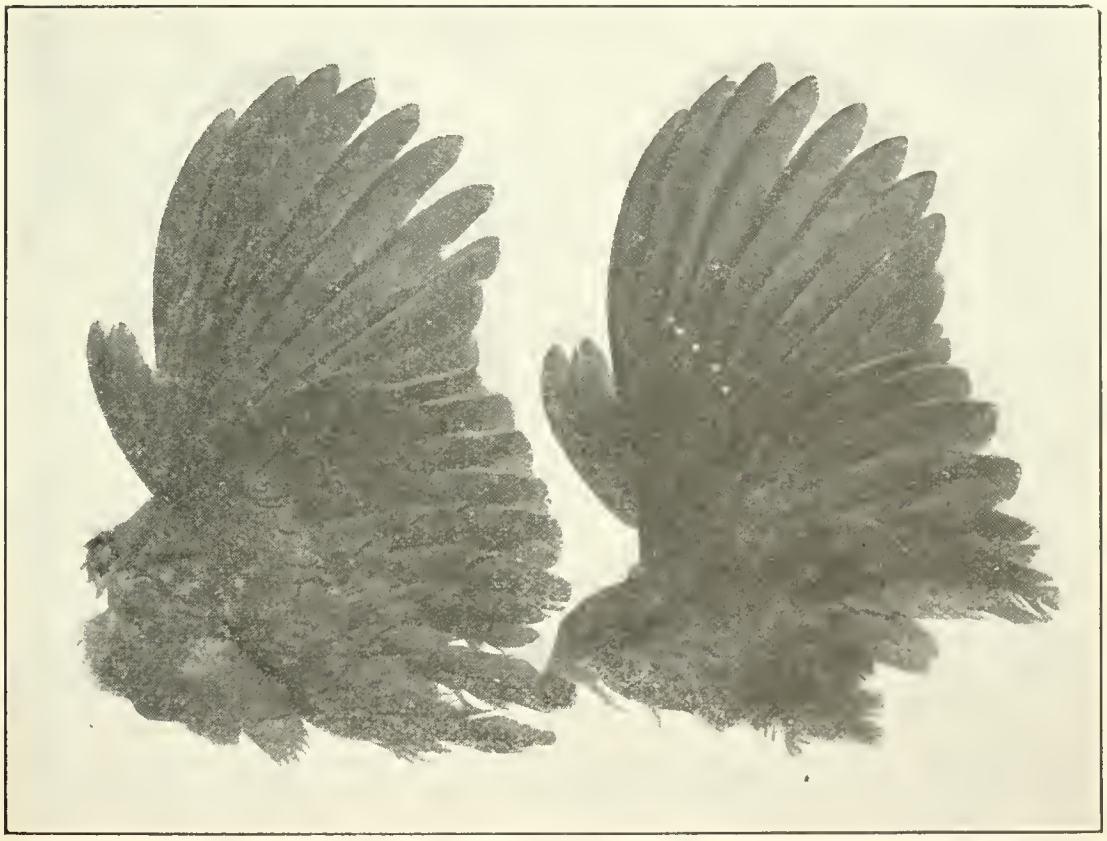

FIG. 9. Wing of adult quail (left), and of immature quail, less than one year old (right). The latter shows the buffy-white spots on the upper primary coverts which serve to distinguish birds of less than one year from the adults.

Use of Juvenal Plumage Characters for Age Diagnosis. Upon the acquisition of the first fall or adult plumage, commencing about the eighth week, all of the grayish-buff, brown spotted juvenal plumage is lost except the primary coverts and outer pairs of primaries. The innermost six primary coverts of the juvenal plumage are "clay color," barred and striped with buffy white, in which respect they differ from the fully adult plumage, as shown in Fig. 9.

Because these mottled coverts are not lost until the second autumn after hatching, they furnish a reliable indication that birds possessing them are not more than one year old. Birds with mottled coverts breed during their second summer (that is, when one year old) just

as freely as do the older birds; however, since in their second fall molt they finally lose these feathers, early in August before the ensuing crop of young (which are markedly smaller in size) has begun to take on this plumage, there is never any chance of confusing the two generations upon the basis of this character.

The fact that the young of a given season may be distinguished from their parents for a whole year thereafter is of considerable importance to hunters and game managers, as pointed out hereinafter.

GENERAL BEHAVIOR AND MISCELLANEOUS HABITS OF QUAIL

ROOSTING HABITS

Behavior at Roosting Time. Unless they have been disturbed a short time earlier, the members of a covey come out into the open just at dusk and feed rather close together, uttering their low clucking and cheeping notes. Then, as the proper degree of twilight arrives, one or two birds will stop feeding, take several hesitant steps in the direction of cover, and suddenly launch into the air with a whir of wings, heading straight for the roosting site.

If the covey has been feeding some distance from cover, as for instance in the middle of a barley field, so that the birds are a little nervous, the entire flock rises at once, with a thunderous roar, and accompanies the leaders. On the other hand, if the site of the evening meal is close to cover, so that the birds feel at ease, they may leave in straggling groups of three or four. Even in such a case the entire covey is at the roost within about 1½ minutes following the arrival of the first individuals.

Having reached the roosting tree, or trees, the birds take from two to about ten minutes to settle themselves for the night. Some individuals hop from twig to twig, calling *plit-plit* excitedly, and causing the branches to bounce and sway with their motions; others come sailing in on set wings and plump themselves down into the foliage without any further noise. As the minutes pass and the twilight deepens, while the horned owls commence to boom, the commotion in the roosting tree subsides; a single bird may call *cu-cá-cow* once or twice as if to reassure itself of the near presence of its companions, and then all becomes silent.

Ground Roosting. It is commonly believed that California quail always roost in trees, or at least off the ground. This is not strictly true, although the proportion of ground to arboreal roostings is probably less than 1 to 1000. The one instance of ground roosting personally observed by the writer was recorded in the field note book as follows:

"Sept. 5, 1933. . . . Incredible though it may seem, about twelve quail were roosting in a compact bunch on the *ground* in an open field. The field is covered with a dense, unbroken stand of tarweed (*Hemizonia congesta* [Fig. 10]). I first saw the birds while driving over the field at about 9 p.m.; the birds did not fly, but their running could be traced by the waving of the dense herbage in front of the head lights. Jumping out of the car, and pursuing them with a flashlight, I caught four by hand, the dense viscid tarweed hampering

them in their efforts to take wing; the others eventually succeeded in launching into the air. I cannot be sure of the cause of this extraordinary choice of a roosting site. Of course the *Hemizonia* was seeding abundantly, providing a fine evening meal, as well as dense cover. A Cooper hawk was in the vicinity this evening and may have frightened the birds so that they did not dare to fly to the trees."

Types of Roosting Cover. The preferred type of roosting cover is furnished by a considerable variety of trees having characteristically dense foliage, and in addition to the species listed in this paper (Part II) there are doubtless others in use locally.

FIG. 10. Ground roosting site in field as described in the text. Solid area of low, light colored plants represents tarweed (*Hemizonia congesta*); tall, dark weeds in left foreground are curly dock (*Rumex crispus*).

The height above the ground chosen by the birds seems to be determined largely by the location of the densest shelter in the tree concerned. Thus, in small dense live oaks, it is sometimes no more than 11 or 12 feet, while in the case of very large, densely foliaged California laurels it is occasionally as great as 35 feet. In the majority of cases, however, the roosts of the birds are to be found between 20 and 25 feet.

In the arid parts of southern California, trees dense enough for roosting are scarce or even absent, and in such cases the birds are obliged to use the low, open brush for this purpose. Under such conditions they may roost anywhere from a few inches to two or three feet above the ground, or possibly on it in some cases; but the inadequacy of the protection offered by such cover is reflected in the abnormally heavy mortality caused by owls.

Occasionally, quail roost in dense tangles of brush when these offer unusual security, even where tree roosting sites are abundant. For example, a covey of quail in the Santa Cruz Mountains regularly roosted at a height of two to ten feet above ground in various impenetrable tangles of poison oak which covered large areas in their territory (Figs. 6, 11).

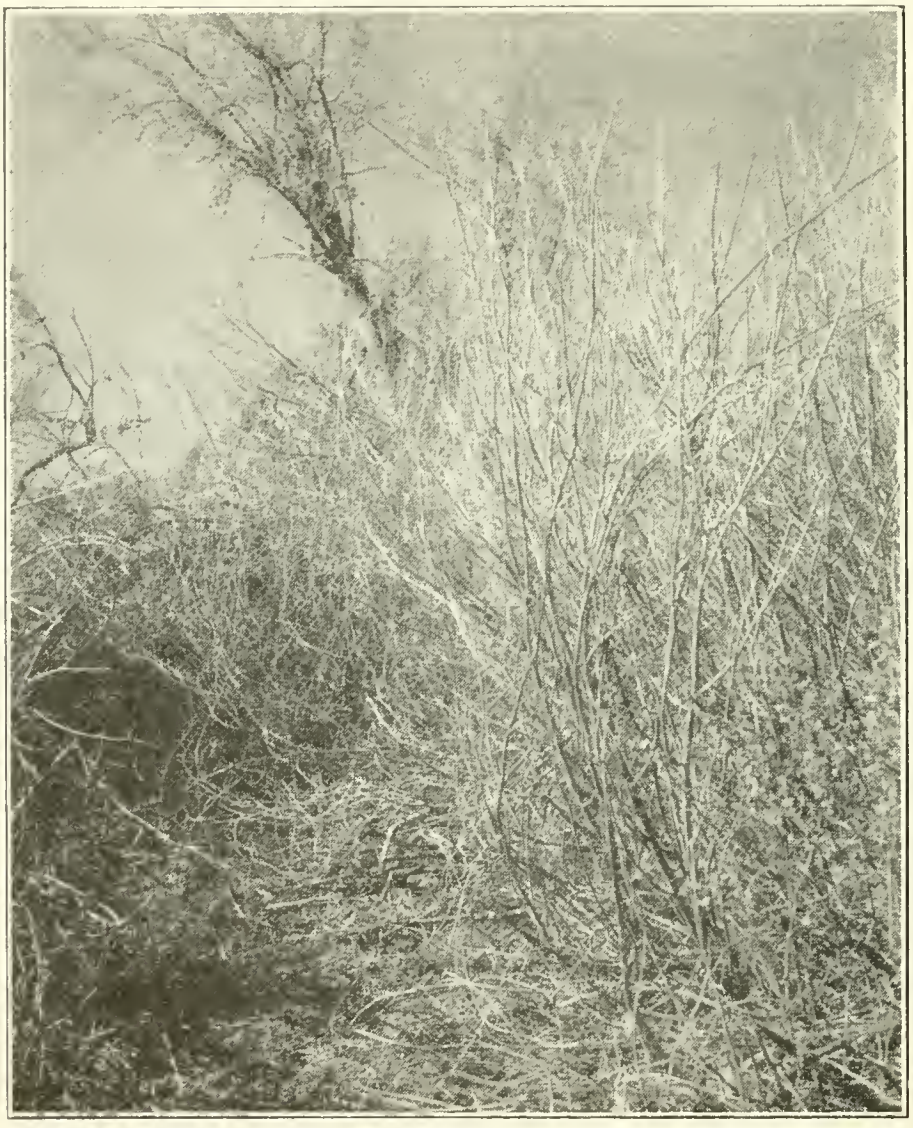

FIG. 11. Dense tangle of poison oak (*Rhus diversiloba*) about seven feet high and covering many hundred square feet, in which a covey of quail habitually roosted. This tangle is one of several shown in Fig. 6.

Position During Roosting. Numerous observations made at night with the aid of a flashlight showed that, although some birds might roost within a few inches of each other, occasionally even touching, the covey was usually scattered rather widely through the roosting tree, provided perching facilities were adequate. If two or more suitable roosting trees were close together, the birds would spread out into these, while certain lone birds might spend the night fully twenty feet from their nearest neighbors. Sometimes at roosting time a covey would divide into two groups which would fly to trees as much as 200 feet apart.

Roosting birds showed a marked tendency to perch in the crotches of small branches, and in places where small lateral branches diverged from an upright trunk (Fig. 12). The birds would snuggle as close as possible to the upright branches, which reduced the chances of their outlines forming a silhouette from any angle and rendered them almost invisible. On more than one occasion the writer has crouched for hours beneath a low, dense tree which was known to contain ten or more roosting quail, without being able to locate more than one or two of them, despite the fact that the belly patches of the birds are fairly conspicuous when seen from below by the glare of a powerful flashlight.

FIG. 12. Diagram showing roosting position commonly assumed by California quail in forks of small branches in dense foliage.

Whether or not quail roost at night with their heads beneath their scapulars was not determined, but a quail which was asleep during the daytime was observed in this position.

Power of Vision at Night. Like the majority of day birds, quail display poor vision at night, and once darkness has set in are loth to leave their roosts unless driven by the most extreme urgency. Birds which are frightened from their roosts fly hesitantly and act as though lost, even on moonlight nights in territory where they have spent their entire lives. Although they seem to know enough to steer toward trees or brush under such circumstances, they alight blunderingly on top of the foliage and remain there for several minutes before making their way gropingly down into the sheltered interior.

Undoubtedly the slow flight and bewildered manner shown by the birds at night makes them easy prey for owls and other night enemies, once they have been forced from their roosts. Their inability to see in the dark also explains their tendency to remain on their perches in the face of a brilliant flashlight beam—often to the point where it is possible, by careful maneuvering, to catch them by hand, as is the case of various other day birds.

Time of Roosting. The time of roosting is determined by the intensity of the light, rather than by the hour as recorded by the clock, and consequently it varies according to the season of the year, as shown by Table 4. The state of the light at roosting time is what may be described as "deep dusk," in the absence of foot-candle ratings, and it undoubtedly represents the minimum illumination at which the birds are able to perceive the approach of enemies or pick out the proper sites for roosting. At such times there was always enough light to enable the writer to distinguish nearby objects, but coveys of quail feeding on plowed ground at a distance of 100 yards were invisible; it was the time of day when the small passerine birds gave their evening chorus and flitted restlessly through the shrubbery as they, too, prepared to go to roost.

That quail react with remarkable uniformity to changing light intensity is shown by the fact that all the birds in a given section go

TABLE 4

RELATION OF HOURS OF ROOSTING AND AWAKENING TO THE SEASON OF THE YEAR

* = 2nd Year of Observation

Month	Day	Roosting hour (P.M.)	Awakening hour (A.M.)	Time spent on roost (hrs., min.)
December	2	5.00		
January	5	5.10*		
January	8	5.25*		
January	14	5.34*		
February	6	6.00*		
February	9	6.00*		
February	18	6.08*		
March	4	6.22*	5.56*	11.34
March	18	6.43*		
March	21		5.51*	11.07
March	27	6.45		
March	29	6.49*		
April	7		5.31*	10.37
April	8	6.58		
April	13	7.00*		
April	14	7.03*		
April	16	7.00		
April	17	7.03		
April	18	7.03		
April	22	7.04		
April	23		5.10	10.06
April	24	7.07		
April	26	7.03		
April	27	7.07	4.50	9.43
April	28		5.10	
May	3	7.10		
May	4		4.35	
May	8	7.17		
May	10	7.23*		
May	11		4.05	8.42
May	12	7.25		
May	15	7.23		
May	16	7.25*		
May	17	7.22*		
May	18	7.19 (cloudy)		
May	19		3.56	8.37
May	20	7.19 (cloudy)		
May	22		4.08	
May	23	7.35		
May	24	7.34	3 55	8.21
May	25	7.31		
May	27	7.14 (cloudy)		
May	28	7.20 (cloudy)	3.15*	
May	31	7.35*		
June	1	7.30		
June	2	7.36	4.10 (cloudy)	
June	6	7.30		
June	8		3.59	8.21
June	14	7.45*		
June	15		4.05*	8.19
June	19	7.47		
June	20	7.50*		
July	3	7.52		
July	5		4.10*	8.18
July	28		5.00*	

TABLE 4—Continued

RELATION OF HOURS OF ROOSTING AND AWAKENING TO THE SEASON OF THE YEAR

* = 2nd Year of Observation

Month	Day	Roosting hour (P.M.)	Awakening hour (A.M.)	Time spent on roost (hrs., min.)
August	22	7.05		
August	25	7.09		
August	31	7.00		
September	5	6.55*		
September	19	6.29		
September	20		5.35	11.06
September	25		5.30*	
October	15	5.47*	5.30*	
October	16		6.53*	
November	5	5.26*		
November	23	5.17*		
November	24	5.11* (cloudy)		
November	26	5.15*	6.48	13.33

to roost within a period of about ten minutes. Coveys on the east side of a ridge go to roost slightly earlier than those on the west side of the same ridge because darkness comes a trifle earlier for the former. On cloudy evenings, when the illumination is less than usual, the birds fly up to their perches at a correspondingly earlier time, as Table 4 shows. A still more remarkable illustration of the uniformity of the roosting hour under given light conditions is provided by the fact that, although the figures given in the table represent observations during two different years, yet when combined into one seasonal cycle they dovetail perfectly; moreover, the covey upon which the observations were made was not entirely composed of the same individuals during the two years. As a matter of fact one can predict within two or three minutes, often less, just when a given covey will go to roost, when once the daily rhythm for that particular locality has been ascertained.

As shown in the table, due to the seasonal fluctuation in the roosting hour, from 5.00 p.m. to approximately 8.00 p.m. together with a corresponding but reverse fluctuation in the hour of awakening, the length of time spent by quail on their roosts varies from 8 hours, 18 minutes, in July, to 13 hours, 33 minutes, in November, and possibly still more in December and January. These figures indicate that possibly the northward limit of range of the California quail may be determined in part by a less than optimum daily period of time available for foraging during the winter months, especially when the presence of snow increases the difficulty of obtaining food.

Frequency of Use of a Given Roost. The frequency with which a given roost is used depends in part upon local circumstances such as the availability of other roosts, and the distance of the covey from the roost at the end of the day. In the Santa Cruz Mountains, where roosting cover is extensive, the birds frequently fly to the nearest

available tree, and since the whereabouts of a covey within its territory is largely dependent upon chance, the choice of a roosting site depends upon the same factor. Sometimes a given roosting tree will not be revisited for more than a week; and because of this irregularity, it has not proved possible in the region mentioned to use droppings as indicators of quail abundance or for any other purpose involving accurate estimates.

Awakening Habits. In the morning, quail frequently start calling from their roosts at an hour when the degree of illumination corresponds roughly to that of roosting time. Low, "conversational" clucking notes can be heard from the dark canopy of foliage, and occasionally a male bird will burst out with a ringing *cu-ca-ców*. During the breeding season this period of early dawn is enlivened by the chorus of *cow!* notes uttered by the unpaired males. This is the time of day when the song-birds are also chirping and calling, but whereas such small birds are already up and about, the quail have not yet moved from their roosts.

Contrary to prevalent opinion, California quail are late risers as compared with the passerine birds. Usually quail will remain on their roosts from six to fifteen minutes after the smaller birds are astir, while on especially cold winter mornings they sometimes do not fly down for nearly an hour. Like the bobwhite, which also dislikes to move about on cold or wet mornings (Stoddard, *op. cit.*, p. 55), California quail even after having left the roost will often stand about listlessly in groups, with their feathers fluffed out, or run stiffly for a few steps to peck at some morsel, and then stop and stand all hunched up. It is because of this dilatoriness that the hours of awakening recorded in Table 4 show less uniformity than do the hours of roosting.

Of course, during summer, when the weather is warm even in the early morning and there is little or no dew, the birds are more lively, especially the unmated males that rise with the song-birds and commence their matutinal calling.

DUST BATHING AND RESTING

With the exception of the breeding season, when courtship activities and the care of the young occupy most of the day, there is little left for quail to do after they have breakfasted and visited water. Some wander about picking up a morsel here and there in a leisurely fashion; others stand for long intervals dozing, with feathers fluffed out and head depressed, their eyes slowly closing and then blinking open again almost immediately as the birds glance around for danger before venturing upon another momentary nap. Still other individuals scratch and wallow in the earth, dust bathing like chickens; they kick out with first one foot and then the other while lying over on the opposite side; and then, returning to a sitting position, with fluffed up, vibrated plumage, they work down into the loose earth which they have scratched up. Damp earth, close to a spring or when caused by a light shower, seems to stimulate the birds to unusual bathing activity. It is also common to see two or three individuals use a "bathing hole" one after another, which of course may facilitate the transmission of lice and other organisms capable to bearing disease.

The period of inactivity just described is especially characteristic of the warm hours of the forenoon and early afternoon; however, local incidents may modify the schedule at any time. The sudden appearance of a Cooper hawk, for example, may force the covey to drop its indolent repose at an instant's notice and scramble wildly for cover, where the birds may crouch for an hour before they dare venture into the open again.

With the passing of the hours the urge to drink may assert itself again, or the birds may all get up and wander off for no discernible reason. Then, as the afternoon becomes cooler, a certain amount of feeding commences, together with more dozing, dust bathing, and occasional sudden frights, until at length it is evening. Appetites now begin to assert themselves and feeding becomes the main business, with the additional necessity of another drink if it is midsummer, after which it is time to go to roost, and another day is done.

PSYCHOLOGICAL TRAITS

Although quail are noted for their wariness, numerous observations made during this study have shown that this wariness results from a natural timidity and nervousness, rather than from any unusual mental powers. However, they undoubtedly possess a retentive memory as regards fear experiences. Certain coveys which were hunted regularly in order to obtain specimens soon became so wild that they would flush at a distance of 150 feet or more and immediately fly into the depths of the woods, where they would perch in scattered formation in the tree tops and utter no sound for more than an hour thereafter. In another case wherein a covey of birds inside the large inclosure was caught by hand at night and greatly frightened, the birds did not once venture out into the open to feed during the following forty-nine days!

The natural timidity of the birds is further shown by the fact that several days after small passerine birds have learned to visit the traps freely, the quail are still reluctant to enter such structures.

The rather low degree of intelligence which quail display, disregarding their natural timidity, is shown by their inability to cope with situations requiring more than the stereotyped reactions provided by habit and instinct. For example, when a family of young quail was confined by itself in a small, open-topped pen whose wire sides were only twenty-one inches high, the parents, instead of hopping or flying over this insignificant barrier to reach the young, ran back and forth all day long at the base of the wire, futilely trying to thrust their heads through the meshes. Even when a slanting wire screen was laid from the top of the pen walls to the ground outside, so that the parents could easily walk up the ramp thus provided, they took no advantage of this aid but continued their endless pacing up and down. In another case a female, confined with her brood inside this small pen tramped to death by her blind, interminable running along the base of the walls, three of the thirteen young which trailed along, cheeping and tired, behind her. To other kinds of birds, especially jays and thrashers, which are not so circumscribed by inborn terrestrial tendencies as quail, this twenty-one inch strip of netting constituted no obstacle at all, either to egress or ingress.

The lack of modifiability shown by quail, which sometimes require two or three years to learn to eat a new food, even though it may be abundant, is a further indication of the intellectual limits of the birds.

In contrast to the lack of mental adaptability just cited, may be mentioned the unique incident described on page 216 wherein a male quail seemed to know that he could force his attentions upon a certain female with impunity at a time when the true mate of this female was not on guard. That quail may learn to modify their innate habits after a time is also demonstrated by the reactions of certain birds inside the large inclosure, that at first used to bump their heads severely against the low wire top at roosting time, but after the first ten days learned to check their flight before striking it.

In short, the California quail appears to be a creature possessing no more than average avian intelligence, whose everyday activities are largely dominated by instinct reinforced by habit. Certain fundamental behavior patterns, together with a marked natural timidity, suffice it for solving most of the emergencies which it encounters, and where this equipment fails and the individual perishes, the species is preserved by reason of its high fecundity.

RELATIVE UNIMPORTANCE OF HEARING IN DETECTION OF DANGER

Like various other species of birds observed by the writer, quail place little reliance upon sound (other than their own alarm notes) as a warning of danger, unless they have learned through experience to associate a definite sound with some definite danger. Even hearing the whirring noise of some other covey in full flight seems to make little impression upon them, provided no alarm notes are audible; likewise the commonly uttered *kek-kek-kek* note of their arch enemy, the Cooper hawk, produces no observable effect upon quail which are nearby, perhaps because the hawk makes this noise when it is perched in the thick foliage where the birds can not see it.

Similarly the birds inside the large inclosure, although they fled precipitately whenever they perceived the least motion through a hole in the blind, yet showed no concern when loud hammering sounds were made inside. The most striking example of the indifference of quail to such sounds was shown by a male quail which walked along the top of a fence with perfect composure while eight shots were fired toward him from a concealed point thirty feet distant with a .22 rifle.

The warning cry of the California jay, which is sometimes heeded by quail, has probably become associated with danger as a result of actual experience. The utility of this note, from the standpoint of quail, is discussed on page 240.

MORTALITY

NEST FAILURES

The percentages of successful and unsuccessful nestings of quail were not determined directly in the case of the present study, due to the difficulty of locating enough nests; however, an approximation of the percentage of nest failures may be obtained by another method.

Various observers have recorded the percentage of nest failures for different species of birds as follows:

Species	Nest location	Percentage of failure	Authority
Bobwhite	Ground	64 (nests)	Stoddard (1932, p. 184)
Ruffed grouse	Ground	57 (nests)	Bump (1933, p. 389)
Horned lark (*Otocoris alpestris*)	Ground	58.7 (eggs)	Pickwell (1931, p. 110)
Song sparrow (*Melospiza melodia*)	Open nest, above ground	59 (eggs)	Nice (1933, p. 130)
Miscellaneous passerine species	Mostly open nests, above ground	52 (eggs)	Clabaugh (1925, p. 115)
Tree swallow (*Iridoprocne bicolor*)	Bird boxes	40 (eggs)	Low (1933, p. 87)
Blue bird (*Sialia sialis*)	Bird boxes	25 (eggs)	Low (1934, p. 41)

From these data it might be judged that the percentage of nest failures for California quail amounts to near 59 per cent; on the other hand, it seems likely that it was not quite as high as that of the bobwhite quail, in the unusually favorable region covered by the present study, where the grazing factor was insignificant, farming activities unimportant, rains absent, and cover ideal. Accordingly, we may arbitrarily assume that the percentage of nest failures was about 60, and then check this figure with the known resident population of adults and young, as revealed by banding studies.

As recorded below (page 246), 175 young were produced during the breeding season of 1933 in an area which supported an adult population definitely known to total 31 potential pairs. If 40 per cent of the 31 pairs, that is to say 12.40 pairs, successfully hatched out 9 young each (average number according to field observation) at the first attempt, there would be produced a total of 111.6 young. But of the 18.60 unsuccessful pairs, most or all (for the sake of simplicity we will here assume all) probably made a second attempt, which, being also 40 per cent successful, resulted in 7.44 additional pairs, producing 9 young each, that is to say 66.96 young at the second attempt. The total number of young hatched out would, according to the above calculations, amount to 178.56, which is as close to the number observed in the field—175 individuals—as one could reasonably expect. Third attempts at nesting, as also the possibility that because of sterility or similar reason the observed number of 34 males and 31 females failed to make 31 pairs, have not been considered in the above calculations because such factors would tend to counterbalance one another, and because their inclusion would over-complicate the presentation of the matter. Another inaccuracy is introduced by the fact that the average figure of 9 young, used here, pertains to families seen in the field from one to seven days after hatching, during which time, of course, such family groups have already suffered a varying, undetermined mortality. Furthermore, some young undoubtedly perished before the census of the total quail population could be taken by trapping.

However, these two factors also tend to cancel each other. Of course the mortality rate will vary from year to year, even in the same locality, due to climatic conditions, while in localities whose respective environments differ widely the discrepancy between the mortality rates may be still greater. Nevertheless, according to the figures given above, the figure 60 per cent, which was assumed to represent nest failures in this particular locality, seems to be substantiated.

This heavy loss of nests is compensated for under normal circumstances by the large number of eggs laid by quail, and is therefore not in itself serious from the point of view of the game manager.

MORTALITY AFTER HATCHING

It is exceedingly difficult to follow the fortunes of any considerable number of broods of small young in the field on account of the extreme secretiveness of the parents during this period. For this reason no exact figures are available to show the actual extent of mortality of such small young. However, since the average number of eggs laid by the California quail is about fourteen (Grinnell, Bryant and Storer, 1918, p. 522), and since the average number of young per family was observed to be only nine at the end of the first week, as previously mentioned, the loss during this first week (disregarding the possible failure to hatch, of any of the eggs of a set, which appears to be comparatively rare) is seen to be $^5/_{14}$ or 35.7 per cent. After the first week, by which time the least fit individuals will have been weeded out, the mortality rate doubtless decreases, so that the loss for the first month may be slightly more than the figure of 39.6 per cent estimated by Errington (1933b, p. 132) for the bobwhite at the end of this period.

By late fall the now well disciplined coveys, made up of the remnants of several family groups, are able to pass through the winter with relatively small losses. The subject of mortality rate of quail after the first month of life is treated more fully on page 246.

Elements. As regards the small young, the poor protection against rain and fog offered by the natal down and the fatal effects of heavy fogs and late rains upon such birds have already been pointed out (page 218), as has also the fact that the breeding season of quail is so timed as to escape such adverse conditions during normal years. Accordingly, the mortality from this source must ordinarily be slight.

In the case of the adults in the Santa Cruz Mountain area, where the winters are mild, with snowfall light and often wholly absent, only insignificant losses are directly attributable to the elements; however, in the northern parts of their range, and in the foothills of the Sierra Nevada, considerable mortality is sometimes caused by heavy snows.

Of more serious consequence to the California quail than stormy weather is a period of drought of a degree sufficient to check the growth of green vegetation prior to the breeding season. If the winter rains fail to produce an adequate supply of green forage, the resulting food shortage (together with a possible vitamin deficiency) is reflected in the poor physical condition of the birds, which may entirely prevent them from breeding in those parts of the State most seriously affected.

Thus, during the winters of 1931–1932 and 1932–1933, when the rainfall was fairly adequate, quail increased noticeably throughout the State. During the winter of 1933–1934, which was exceptionally dry, with green food reduced to a fraction of the normal amount, many flocks of quail in the arid parts of Los Angeles and San Diego counties failed to break up into pairs, so that no young at all were produced, while in other large areas also affected by drougth the crop of young birds was far below the average.

Natural Enemies. Although the natural enemies of quail are responsible for a slow, steady drain upon quail populations, this mortality does not reach serious proportions as long as the food supply of the birds remains adequate for maintenance of vigor. When the food supply dwindles, however, especially during the winter season, the birds become weakened and are easily captured by even the slower predators; moreover, the strong, vigorous birds are compelled to forage farther from protective cover, so that they, too, fall prey to enemies in greater numbers than normally. When the surplus has been removed, and the birds reduced once more to the carrying capacity of the range, losses fall back to normal.

COOPER AND SHARP-SHINNED HAWKS

Cooper and sharp-shinned hawks, especially the former, are the most destructive of all enemies of quail. If unsuccessful at the first attempt to catch a quail, these hawks frequently perch motionless in a nearby tree or bush, waiting for the covey to venture out into the open again after it has recovered from its fright.

According to field observations, Cooper hawks can fly about as fast as quail, but not much, if any, faster, so that if the latter have a few feet head-start their chances of reaching safety are good. A hawk relies upon surprising its quarry, as a rule, rather than in overtaking it by sheer speed; however, if cover is adequate, the wariness of the covey is usually sufficient to enable it to escape, since it has the advantage of its many pairs of eyes to keep watch for danger.

Both Cooper and sharp-shinned hawks are far more adept at flying through thick cover than other hawks; indeed, the writer once saw a sharp-shin fly faster and with more agility than any quail through a dense stretch of woods which was almost impenetrable to a human being, the bird holding its course only three feet above the ground, where it encountered a minimum of obstructing branches. Hawks of these species readily enter quail traps and are thus a serious nuisance when banding activities are being carried on.

Continued harassment by enemies may have an adverse effect upon game by preventing it from feeding, thereby weakening it. In this connection it is worthy of note that the stomach of a quail, shot by the writer from a covey which had been prevented by a Cooper hawk from feeding just before going to roost, was practically empty.

On the other hand, the damage done to quail by these hawks in localities where there is plenty of food and cover is not serious. In the region covered by the present study, Cooper hawks were unsuccessful in every attempt to catch adult quail that was observed by the writer; two three-quarters grown young were seen to be taken.

Male sharp-shinned hawks, because of their small size, appear not to be able to capture adult quail; furthermore, they are on their breeding grounds, which are for the most part north of the range of

TABLE 5

STOMACH CONTENTS OF COOPER HAWKS (ACCIPITER COOPERI) TAKEN ON QUAIL REFUGES

Date	Locality	Contents	Remarks
Jan. 3, 1932	Santa Cruz Mountain study area	Feathers of domestic pigeon	Many killed by these birds
Nov. 30, 1932	Santa Cruz Mountain study area	Golden-crowned sparrow (*Zonotrichia coronata*)	
Nov. 30, 1932	Santa Cruz Mountain study area	Meadowmouse (*Microtus californicus*)	
Mar. 26, 1933	Santa Cruz Mountain study area	Steller jay (*Cyanocitta stelleri*)	
Sept. 20, 1933	Santa Cruz Mountain study area	California quail, juv. male	
Oct. 1, 1933	Near Lancaster, Los Angeles County	2 lizards (*Sceloporus* sp.)	
Oct. 7, 1933	Santa Cruz Mountain study area	California quail	
Dec. 21, 1933	Near San Bernardino, San Bernardino Co.	California quail	
Dec. 28, 1933	Near San Bernardino, San Bernardino Co.	California quail	Game-farm-raised bird
Jan. 5, 1934	Near San Bernardino, San Bernardino Co.	California shrike (*Lanius ludovicianus gambeli*)	
Jan. 12, 1934	Near San Bernardino, San Bernardino Co.	California quail	Game-farm-raised bird

STOMACH CONTENTS OF SHARP-SHINNED HAWKS (ACCIPITER VELOX) TAKEN ON QUAIL REFUGES

Oct. 10, 1933	Near San Bernardino, San Bernardino Co.	California quail	Game-farm-raised bird
Nov. 14, 1933	Near San Bernardino, San Bernardino Co.	California quail	Game-farm-raised bird
Nov. 27, 1933	Near San Bernardino, San Bernardino Co.	California quail	Game-farm-raised bird

the California quail, during the season when the young of the latter would be vulnerable to their attacks.

RED-TAILED HAWK

The unimportance of the red-tailed hawk as an enemy of quail, as well as the benefits resulting from its presence, will be pointed out in Part II. In the Santa Cruz Mountain area, where red-tails were abundant, none was ever seen trying to catch quail, nor would they have been able to, under ordinary circumstances, on account of the density of the cover. In parts of southern California, where cover

was markedly inadequate, red-tailed hawks were occasionally observed to catch inexperienced, game-farm-raised birds, as indicated in Table 6; but such occurrences were obviously not representative of the normal relations between the two species.

TABLE 6
STOMACH CONTENTS OF RED-TAILED HAWKS (BUTEO BOREALIS CALURUS) TAKEN ON QUAIL REFUGES

Date	Locality	Contents	Remarks
March, 1933	Near San Bernardino, San Bernardino Co.	California quail	Game-farm-raised bird
April, 1933	Near Lancaster, Los Angeles Co.	Ground squirrel	
Oct. 24, 1933	Near Lancaster, Los Angeles Co.	Pocket gopher (*Thomomys* sp.)	
Nov. 14, 1933	Near San Bernardino, San Bernardino Co.	Cottontail rabbit (*Sylvilagus auduboni sanctidiegi*)	
Dec. 10, 1933	Near San Bernardino, San Bernardino Co.	Meadow mouse	
Dec. 15, 1933	Near San Bernardino, San Bernardino Co.	Sparrow (*Zonotrichia* sp.?) Meadow mouse	

OTHER HAWKS

For a general consideration of the relation of other hawks to quail, see Part II. In addition, the following records of stomach contents were obtained from quail refuges:

Marsh hawk (*Circus hudsonius*), collected October, 1933 near Lancaster, California—one meadow mouse; Ferruginous roughleg (*Buteo regalis*), collected December 26, 1933 near San Bernardino, California—one ground squirrel.

HORNED OWL

Horned owls appear to do no serious damage to quail in areas where roosting cover is abundant. In regions where roosting cover is scanty, horned owls are sometimes important enemies of quail, but this circumstance is primarily due to a faulty environment. The writer has many times observed coveys of quail feeding at dusk in open places, such as barley fields, while several horned owls were booming near-by and some were even visible in the tops of the trees; nevertheless, no attempt was made by these owls to catch the quail, probably because, like red-tailed hawks, horned owls are no match for quail as regards speed of flight during the hours of daylight. Probably most of the quail which fall prey to horned owls do so as a result of being flushed from their roosts, in some cases, perhaps, by another enemy.

OTHER OWLS

For a general consideration of the relations of other owls to quail, see Part II. In addition, the following records of stomach contents were obtained from quail refuges:

Burrowing owl (*Speotyto cunicularia hypogaea*), collected November, 1933, near San Bernardino, California—finely triturated insect

TABLE 7

STOMACH CONTENTS OF HORNED OWLS (BUBO VIRGINIANUS PACIFICUS) TAKEN ON QUAIL REFUGES

Date	Locality	Contents	Remarks
Oct. 1, 1933	Near Lancaster, Los Angeles Co.	Pocket mouse (*Perognathus* sp.) scorpion (Scorpionida)	
Oct. 2, 1933	Near Lancaster, Los Angeles Co.	Cottontail rabbit (*Sylvilagus* sp.), fragment of snake (sp?)	
Oct. 7, 1933	Near San Bernardino, San Bernardino Co.	2 scorpions, 1 Jerusalem cricket (*Stenopalmatus* sp.)	
Oct. 28, 1933	Near San Bernardino, San Bernardino Co.	Fragments of cricket	
Nov. 4, 1933	Near San Bernardino, San Bernardino Co.	Fragments of cricket or grasshopper	
Nov. 7, 1933	Near San Bernardino, San Bernardino Co.	Fragments of four crickets	
Nov. 10, 1933	Near San Bernardino, San Bernardino Co.	California quail fragment of mouse (sp?)	Roosting cover inadequate
Nov. 18, 1933	Near Lancaster, Los Angeles Co.	Jerusalem cricket, horned lark (*Otocoris alpestris*)	
Dec. 6, 1933	Near San Bernardino, San Bernardino Co.	Fragments of 2 crickets (?)	
Dec. 7, 1933	Near San Bernardino, San Bernardino Co.	Fragment of cricket, rodent hair (mouse?)	
Dec. 7, 1933	Near San Bernardino, San Bernardino Co.	Fragments of crickets, brush rabbit (*Sylvilagus* sp.)	

remains, many of beetles; Short-eared owl (*Asio flammeus*), collected December 14, 1933, near San Bernardino, California—feathers of sparrow (sp. ?); Long-eared owl (*Asio wilsonianus*), collected November 28, 1933, near San Bernardino, California—kangaroo rat (*Dipodomys* sp.).

JAYS

Where cover is adequate jays appear to do no significant damage to quail. Moreover, the California jay (*Aphelocoma californica*) is of some benefit to quail by reason of its habit of uttering a certain loud, sharp *cha!* note at the approach of a Cooper or sharp-shinned hawk. Usually, although not always, quail (and also sparrows) dive precipitately into cover upon hearing this noise; however, the jays often fail to give this note in the presence of the hawk, so that, in view of the wariness of the quail themselves, the importance of jays to the latter in this respect is not vital. Out of six cases in which jays were known to have observed the approach of a Cooper hawk, the birds gave the warning note on four occasions, remaining silent two times.

SNAKES

The relation of snakes to quail is discussed as completely as the facts at hand permit in Part II. Mr. Allan McKean, formerly Research Assistant for the Division of Fish and Game, informed the writer that he had watched the actions of a king snake which was trying to capture some young quail. Contrary to popular legend, the adult quail were not at all "hypnotized" by the snake, but ran about in front of it, the female trying to decoy it away as she fluttered on the ground with trailing wings.

The snake followed the adults for only a few feet and then returned to the place where the baby quail were, but could not locate any. Presently the adults called their young over to a thicket one hundred feet distant. For a considerable time after this, the snake remained where it was, but just at dusk it again moved over to where the family of quail was, as though guided by the sounds (?) made by the birds. When dusk fell McKean collected the snake and found that its stomach was empty. He believed that as a result of the activities of the reptile some of the young had become scattered and lost, which at their age could only prove fatal.

HOUSE CATS

Feral house cats are commonly regarded as excessively destructive to bird life, although published records of stomach contents are rare. The following records from the Santa Cruz mountain study area, although admittedly meager, indicate that, like other predators, house cats prey upon whatever is most abundant and easiest to capture—in which category quail are not to be classed:

December 22, 1932, 2 meadow mice, 1 brush rabbit; May 16, 1933, 1 one-fourth grown brush rabbit; September 1, 1933, 1 white-footed mouse.

BOBCATS

The effect of bobcats upon quail is discussed in Part II. Stomach examinations bear out the conclusions reached, as follows:

TABLE 8

STOMACH CONTENTS OF BOBCATS (LYNX RUFUS CALIFORNICUS) TAKEN ON QUAIL REFUGES

Date	Locality	Contents
Jan. 25, 1933	Near San Bernardino, San Bernardino Co.	Jack rabbit (*Lepus californicus*)
Mar. 13, 1933	Near San Bernardino, San Bernardino Co.	Fur of rabbit (*Sylvilagus* sp?)
Feb. 8, 1933	Near San Bernardino, San Bernardino Co.	Fur of rabbit (*Sylvilagus* sp.?)
Oct. 7, 1933	Near San Bernardino, San Bernardino Co.	Western tanager (*Piranga ludoviciana*)
Nov. 29, 1933	Santa Cruz Mountain study area	Wood rat
Dec. 1933	Santa Cruz Mountain study area	Brush rabbit (*Sylvilagus bachmani*)
Mar. 10, 1934	Near Lancaster, Los Angeles Co.	Parts of jack rabbit and cottontail rabbit
Mar. 12, 1934	Near Lancaster, Los Angeles Co.	Fur of rabbit (*Sylvilagus* sp?)

Mr. McKean saw a bobcat spring at a quail and miss it—an observation which has been duplicated by other field workers.

COYOTES AND OTHER PREDATORY MAMMALS

That coyotes and other predatory mammals play no significant rôle in the destruction of quail is demonstrated in Part II. The results of stomach examinations are as follows:

TABLE 9

STOMACH CONTENTS OF COYOTES (CANIS LATRANS OCHROPUS) AND OTHER PREDATORY MAMMALS TAKEN ON QUAIL REFUGES

* = fecal material

Date	Locality	Contents	Remarks
		Coyotes	
Feb. 1933*	Santa Cruz Mountain study area	2 brush rabbits, 2 wood rats, meadow mouse, white footed mouse (*Peromyscus* sp.), ground squirrel	Depositions of six individuals
Mar. 1933	Near San Bernardino, San Bernardino Co.	Cottontail rabbit	
Mar. 1933	Near San Bernardino, San Bernardino Co.	Deer belly hair	Carrion?
Oct. 7, 1933	Near Lancaster, Los Angeles Co.	1 ground squirrel (entire), foot of jackrabbit	
Oct. 8, 1933*	Santa Cruz Mountain study area	Brush rabbit, wood rat, ground squirrel, mouse fragments (*Peromyscus* or *Reithrodontomys*)	Depositions of three individuals
Nov. 2, 1933	Near Lancaster, Los Angeles Co.	Fur of rabbit (sp.?)	
Nov. 25, 1933	Near Lancaster, Los Angeles Co.	Ground squirrel	
Nov. 25, 1933	Near Lancaster, Los Angeles Co.	White footed mouse, wood rat, ground squirrel	
Dec. 2, 1933	Near Lancaster, Los Angeles Co.	Fur of rabbit (sp.?)	
Feb. 7, 1934	Near Lancaster, Los Angeles Co.	White footed mouse, ground squirrel fragments, kangaroo rat fragments	
Feb. 27, 1934	Near Lancaster, Los Angeles Co.	Half-grown brush rabbit	
Mar. 1, 1934	Near Lancaster, Los Angeles Co.	Fur of rabbit (sp.?)	
		Badger (*Taxidea taxus*)	
Mar. 11, 1933	Near San Bernardino, San Bernardino Co.	Fur of rabbit (sp.?)	

RODENTS

The relation of various rodents to quail nest destruction should be more fully investigated, particularly in the case of the wood rat (*Neotoma fuscipes*), which is exceedingly abundant in quail territory in the Santa Cruz Mountain area.

That the meadow mouse (*Microtus californicus*) is not an enemy of quail is indicated by the fact that quail eggs were left for weeks, without ever being disturbed, near runways along which these mice were actively foraging.

The rôle of the ground squirrel in the ecology of quail is discussed in Part II.

ACCIDENTS

A surprisingly large number of deaths occur among game birds as a result of accidents of various sorts, chief of which are collisions with objects during flight. Errington (1933c, p. 32) believes "that mechanical accident is a mortality cause much under-estimated by wild life students," and that "in the aggregate perhaps [such accidents] constitute a factor as lethal as any in the life equation of the quail." The present writer is also inclined toward this opinion, to which Table 10 lends support.

TABLE 10

ACCIDENTS TO QUAIL RECORDED DURING THE PRESENT INVESTIGATION

Agent	Number of instances	Circumstances	Result
Moving automobile	4	Birds flushed from roadsides while feeding	Three birds killed; one uninjured?
Fence	8	Collision while in full flight	Six birds killed; one knocked to ground, possibly surviving; one severely wounded but recovered
Tree trunk	1	Collision while in full flight	Bird knocked to ground, probably survived
Unknown, possibly fence	1	Unknown	Bird killed
Water tank	1	Unknown	Bird drowned
Cactus thorn in leg	1 (small young)	Prevented bird from keeping up with the others	Removed by the observer, Mr. Allan McKean

DISEASE

No signs of disease were noted among the quail of the Santa Cruz Mountains, nor is it probable that an outbreak would have been overlooked if it had occurred, especially during the year of intensive trapping when the same birds were handled over and over again.

On the other hand, quite the contrary condition was discovered in the quail population of the 140-acre campus of Mills College, Oakland, California, during the late winter months of 1932–1933. On March 20, 1933, Mrs. E. Lowell Sumner, Jr., found a sick quail standing in a corner outside the Mills College science building. The bird was too feeble to escape, and died twenty minutes after its discovery. It was sent to Dr. M. Hobmaier, Pathologist of the Division of Fish and Game, for examination, who, however, was unable to find "signs of any disease as yet known on quail."

Subsequent to the discovery of this sick bird, the carcasses of four others, evidently at least one month old, were found within a few hundred feet of the same spot, while three additional recently-dead quail were reported during the preceding month. This brought the total known number of dead birds up to eight.

Four more quail were trapped from the spot where the dead birds had been found, and were sent alive to Dr. Hobmaier, but no abnormal condition was discovered, which indicates that the epidemic, whatever its nature, had subsided. Although large numbers of the birds still inhabited the region, no more dead quail were found.

PARASITES

No mortality associated with parasites was observed in the quail of the Santa Cruz Mountains, in spite of the fact that between July 29 and October 7, 1933, at least one out of every five birds harbored a hippoboscid fly, identified by Dr. F. C. Bishopp, United States Bureau of Entomology, as *Lynchia hirsuta*, which is known to transmit the important blood parasite *Haemoproteus lophortyx* of quail (O'Roke, 1932, p. 224). At no time other than the season mentioned were hippoboscid flies found on quail, although the banding program, which involved handling large numbers of birds, would have revealed them had they been present.

POPULATION STUDIES

NUMBER OF QUAIL PER ACRE

From February 1, 1933, to February 1, 1934, as previously mentioned, intensive trapping operations were carried on over an area of approximately sixty acres. The area was particularly suitable for this work because of its natural boundaries, which reduced to an almost negligible quantity the birds' chances of wandering into other regions (Fig. 13).

The problem of expressing in a significant fashion the number of quail to the acre on a given range is more difficult than might at first appear, even when the number of resident birds as well as the total land area is known. For example, in the case of the area shown in Fig. 13, should we include in our calculations all of the heavily wooded, deep ravines shown, which extend in certain directions for miles beyond the limited area included by the map and which act as barriers to the dispersal of the birds? If we do include all this wooded land, which can never become quail environment, then our figure for number of birds per acre must always remain almost vanishingly small, no matter

how much we may increase the number of quail locally, in the open parts of the region, by practicing game management.

A more clearcut example would be furnished by a flock of 500 quail which are restricted to a carefully managed 500-acre estate surrounded by a forest comprising 50,000 acres; should we consider only the region occupied by the estate, together with a narrow strip of adjacent *habitable* woodland and estimate the density at about one bird per acre, which would be a high concentration, or should we include the whole forest and consider the density as approximately one bird per 100 acres, which would be a very low concentration? In the opinion of the writer the former figure would be more significant and therefore preferable, because the wooded portion of the area would constitute almost as effective a natural barrier to the birds as would a desert or an

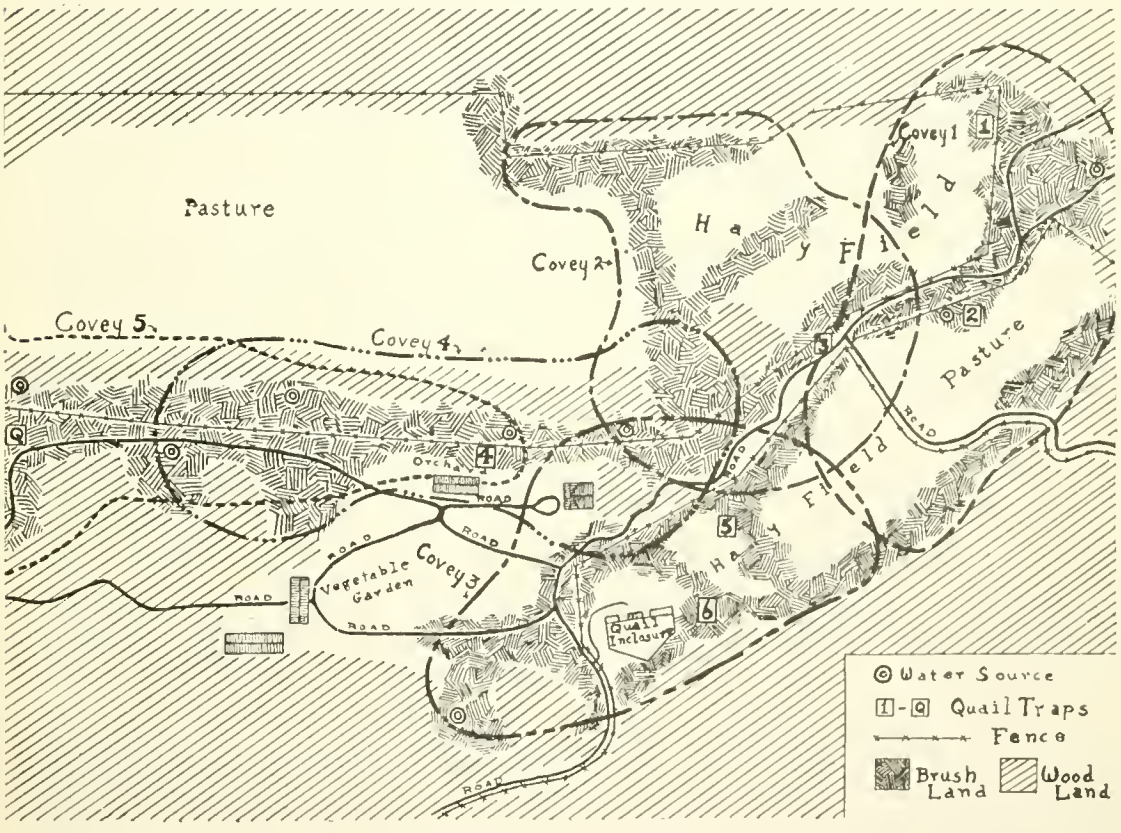

FIG. 13. Area comprising 60 acres of territory habitable for quail where an intensive banding program was carried on for more than a year. The chief headquarters of each covey is shown.

ocean—yet no one would include the acreage of an ocean along with that of a game preserve which bordered upon it.

Accordingly, in the present paper, only the outer margin of forest land, approximately 100 feet in width, has been included in the calculations. Brush land has been included to the full amount of the acreage, in order not unduly to complicate the issue. Similarly, Nicholson (1934, p. 145) has confined his estimates of population densities to the areas actually inhabited, or habitable, by the animals in question.

Large open areas such as bare valley floors would also represent a type essentially uninhabitable for quail and therefore not to be considered in bird-per-acre calculations, but in the case of this study no such areas were present to interfere with estimates of quail per acre.

In the area shown in Fig. 13, approximately 20 pairs out of a total of 64 resident adults (representing a potential of 31 pairs) were successful in raising 175 young to an age of between one and seven days; in other words, 64 per cent of the total of 31 pairs were ultimately successful. This figure must not be confused with the figure of 60 per cent given on page 235, which represents the proportions of nest *failures;* in other words, by making a second attempt after the destruction of the first nest, the species is able to increase its chances of success from 40 per cent to 64 per cent.

Fig. 14 shows a considerable differential mortality between adults and young during the months following hatching, which is in accord with the presumption that young fall prey to enemies in much larger numbers than adults because of the inexperience of the former.

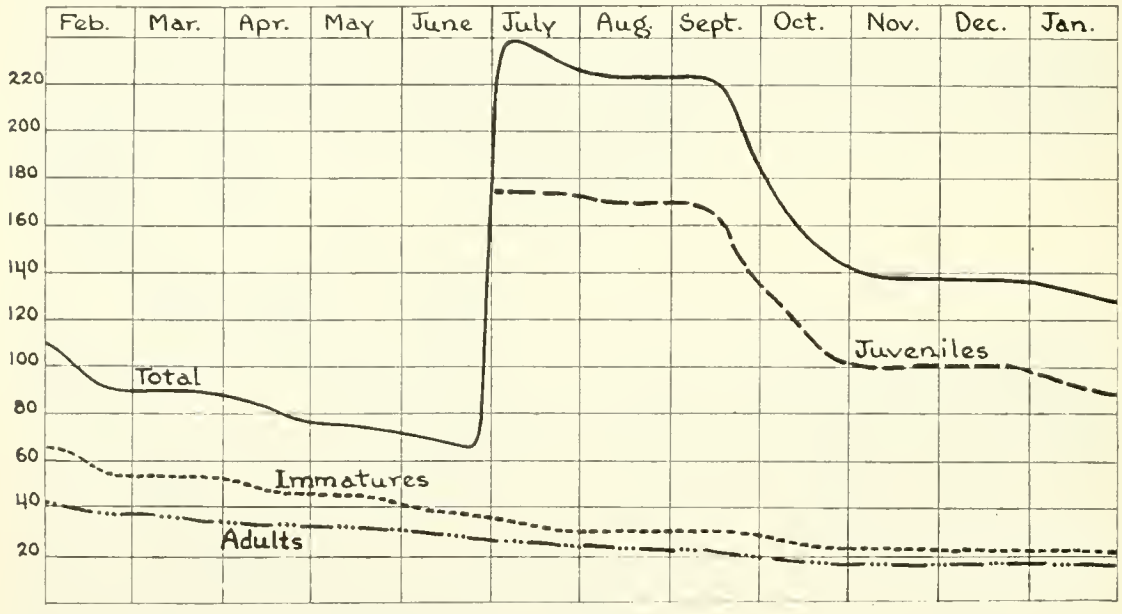

Fig. 14. Diagram showing population fluctuations during one year among quail residing in the 60-acre territory shown in Fig. 13. Actual numbers of birds at left.

It will be observed that, due to a combination of favorable circumstances, chief of which were freedom from overgrazing, an abundant food supply, and no hunting, the quail population in the area studied increased from 105 on February 1, 1933, to 130 on February 1, 1934, although no predatory animal control was carried on. From Figs. 13 and 14 it can be calculated that, in accordance with the season of the year, the number of quail varied from 1.1 to 3.9 per acre of habitable territory.

ESTIMATES OF SHOOTABLE SURPLUS

Obviously, estimates of shootable surplus in quail can only be made upon the basis of local conditions, for the factors governing quail abundance may vary widely within the space of a few miles. Similarly, conditions in a given locality may differ from one year to another as a result of weather differences or changes in human activities.

Bryant (1912, p. 138) has expressed the opinion that a certain proportion of quail may be taken by man during the hunting season, provided that this number does not exceed the number of birds which would have met death during this period as a result of natural forces.

It is the belief of the present writer that the number of birds harvested may somewhat *exceed* the expected casualty rate for the relatively short period of time represented by the shooting season, and that under favorable conditions the shootable surplus may include all birds which would normally have died by the end of February. For example, in the case of the quail in the area shown in Fig. 13, the number of birds dropped, due to natural enemies and related causes, from 139 to approximately 113 between October 30 and February 28, which is a loss of 19 per cent. In view of the fact that the quail population of this locality showed a net increase for the year of 25 birds (Fig. 14), in spite of this loss, there is hardly any doubt that most of the surplus of 19 per cent or 26 birds could have been taken from the area by hunters without detriment, it being understood that the toll levied by natural forces would automatically shrink below the normal figures as soon as the surplus birds had been removed by hunters.

From Fig. 14 it can be seen that if the percentage of young birds taken is consistently less than about 71 per cent of the total bag, it is an indication that the breeding season was not successful, in which case hunting should be discontinued in the region affected, in order not to deplete the breeding stock. For example, during 1934, quail populations in drought-stricken areas such as Los Angeles and San Diego counties, where few or no young were produced, should not be hunted (unless supplemented by artificially liberated birds such as those raised on game farms).

A method of distinguishing young of the year from fully adult birds is described on page 225.

LONGEVITY

From Fig. 14, it can be calculated (after subtracting the net increase for the year, 25 birds) that, out of 100 quail raised in a given summer, 26.8% will be alive at the end of the first year, 7.2% at the end of the second, 2.0% of the birds at the end of the third year, and .5% at the end of the fourth. From this, the average life expectation is seen to be about eight months.

These longevity figures are in general agreement with supplementary survival figures obtained from 35 additional banded quail, as follows: 1-1½years, 26.8% ; 1½-2 years, 12.8% ; 2-2½ years, 7.35% ; 3.2 years, 1.05% ; 3.5 years and still alive, .7%.

SEX RATIO

As indicated in Table 11, there is a greater number of males than females at all seasons, the average ratio being 53.2 to 46.8. In the present study, the data were obtained from birds of all ages except juveniles less than one-third grown. How far back toward hatching time this inequality of the sex ratio extends is not known; at least it is certain that the unequal ratio is not due to any difference between the sexes in their readiness to enter the traps, since all the birds of each covey were known to have been captured.

TABLE 11
SEX RATIO IN A POPULATION OF 280 CALIFORNIA QUAIL DURING EIGHTEEN CONSECUTIVE MONTHS

Date	Males		Females	
	Number of individuals	Percent	Number of individuals	Percent
Jan. 1-15	126	52	114	48
16-31	122	52	113	48
Feb. 1-15	57	54	48	46
16-28	50	55	41	45
Mar. 1-15	50	55	41	45
16-31	48	54	41	46
April 1-15	45	53	40	47
16-30	42	53	37	47
May 1-15	41	53	36	47
16-31	41	54	34	46
June 1-15	38	54	32	46
16-30	35	53	31	47
July 1-15	184	53	160	47
16-31	180	53	156	47
Aug. 1-15	177	53	151	47
16-31	177	53	151	47
Sept. 1-15	177	53	151	47
16-30	166	54	141	46
Oct. 1-15	150	54	126	46
16-31	135	53	118	47
Nov. 1-15	128	52	116	48
16-30	128	52	116	48
Dec. 1-15	128	52	116	48
16-31	128	52	116	48

WEIGHT CHANGES

Seasonal Weight Fluctuations of Adults. As shown in Fig. 15, the adult male weighs most during the winter and early spring months,

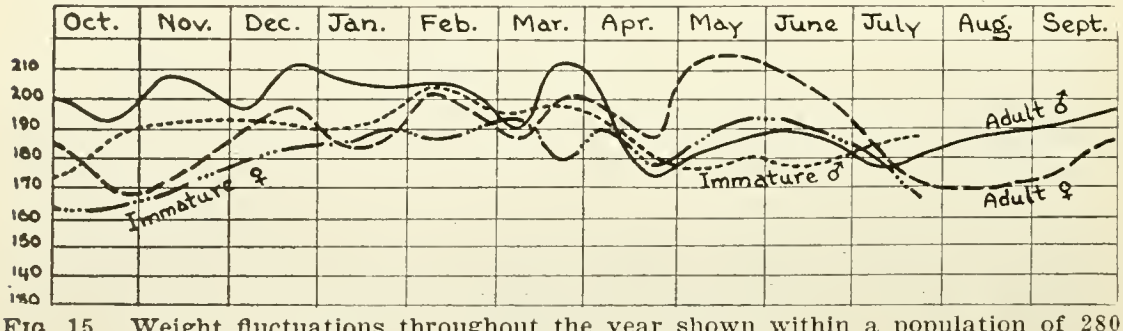

FIG. 15. Weight fluctuations throughout the year shown within a population of 280 quail; 652 weighings are represented.

while the marked decrease in weight suffered during the breeding season is almost certainly caused by the irregular feeding habits and high state of nervous excitement resulting first from pairing activities and later from the prolonged, arduous period of sentry duty. It may be significant in this connection that a nonbreeding male in the large inclosure weighed 198.2 gr. during the period when the average weight for breeding males was 189.4.

In the case of the female, which takes no active part in the strenuous activities of courtship and is relieved of all sentry duty, no loss of weight takes place until after the hatching of the young in July. Indeed, between mid-April and mid-July she is actually heavier than the male, although the reverse of this condition holds during the remainder of the year.

Immature birds of both sexes, since they breed at the age of one year, show weight fluctuations similar to those of the older birds. However, since they do not reach full adult weight until the beginning of the second year, their variations in weight follow, at a lower level, those of the older birds.

TABLE 12

AVERAGE WEIGHTS OF VARIOUS RACES AND LOCAL POPULATIONS OF QUAIL

(*Lophortyx californica*)

Race	Locality	Nearest parallel of latitude	Average weight	Number weighed
L. c. brunnescens	San Mateo Co., Calif.	37°60′	189.5	652
L. c. californica	[1]Tehama Co., Calif.	40°	180.0	11
L. c. californica	[2]Mariposa Co., Calif.	37°60′	166.7	4
L. c. californica	[2]Monterey Co., Calif.	36°60′	185.0	7
L. c. californica	Los Angeles Co., Calif.	34°	159.3	29
L. c. californica	Lower California	32°60′	151.0	8
L. c. plumbea	[2]Lower California	31°	157.7	57
L. c. achrustera	[2]Lower California	28°–24°	150.6	32

[1]Grinnell, Dixon, and Linsdale, 1930, p. 208.

[2]Weights obtained from labels of specimens in collection of Museum of Vertebrate Zoology.

Following the mating season, the period of molt continues the drain upon the vitality of the birds, so that it is only after this has been completed in September that they commence to put on the weight which enables them successfully to endure the rigors of winter.

Daily Weight Fluctuations. Few data on daily weight fluctuations were secured, due to the fact that nearly all birds trapped or shot were taken within about two hours before roosting. Table 3 shows the difference between late evening and early morning weights in the case of 94 birds which were kept over night; the average loss during this period was 5.86 per cent.

Geographic and Subspecific Weight Differences. The California quail in its various races, and even within a given race, conforms reasonably closely to "Bergmann's Law" (Rensch, 1929, p. 133),

which states that within a given species, whose races are distinguishable as to body size, small size is correlated with warm climate and large size with cold climate (Table 12). Bergmann's explanation of this correlation is that with increase in *volume* of a body, from 1 to 8, for example, the outer *surface* increases only from 1 to 4; in other words, a large animal has less surface in proportion to its size exposed to a cold environment than does a small one, and as a result is better protected against heat loss through radiation.

In view of this circumstance, the undesirability of importing lightweight, small-bodied races of quail from southern climates into northern regions is apparent.

PLUMAGES

Time has not permitted the working out of molt sequences, so that the present observations, culled from the writer's field notes, are fragmentary.

The approximate ages at which the young undergo the transition from natal down through the precociously developed juvenal plumage to the first fall plumage have been given on pages 222–225. One curious departure from the normal relation of spotted to unspotted primary coverts (Fig. 9) was observed in a youngster which had the two distalmost coverts mottled, instead of solid black as normally, while the two coverts next to these were solid black instead of mottled—a condition exactly the reverse of normal as regards these four feathers. Both wings displayed this abnormality. A somewhat intermediate condition was found once, in which the distalmost covert was dark, as in the normal arrangement, but the next one to it, although also normally dark, was in this case lightly mottled, like the remaining primary coverts.

The fall molt commences about the first week of August, for both juveniles and adults, and involves the head and neck first. From this point it spreads posteriorly over the body, and is accompanied by the replacement of the primary coverts. During September, molting is at its height; the birds present a ragged, untidy appearance, and in many cases the head plumes of both old and young are entirely absent. By the middle of October the body molt is nearly complete, and the primaries are also being replaced, while by the last week of November only two or three pinfeathers can be found on the entire body, and the birds are resplendent in their new plumage.

The head plumes of quail assume various positions according to the activities, and doubtless the emotions, of the birds. This applies to both sexes, and even to the small young, which have an abbreviated topknot by the tenth day at least, if not from birth. When the birds are relaxed—either wandering about aimlessly, or dozing—the plume droops down forward, fairly overhanging the bill in the case of adult males.

With the assumption of an alert position, however, as in the case of a dozing bird which has been startled, the plume snaps up to a vertical position. Males which are fighting depress the plume so far backward that it lies almost parallel with the top of the head, as though to avoid being injured during the scuffle. In feeding, the plume is

held high up and somewhat backward so that it can not touch the ground. A similar position is also adopted when the birds are frightened.

SUMMARY

FOOD HABITS AND REQUIREMENTS

The pea family provides a larger and more varied food supply than does any other plant family (32.47 per cent of total), with bur clover ranking as the No. 1 quail food throughout large parts of California. Grasses are next in importance to the legumes as a source of quail food (14.4 per cent of total). Damage to grain crops by quail is relatively slight.

Other important foods are the filarees, thistles, buttercups, chickweeds, and docks. A great *variety* of food is eaten, so that very few plants rank as major food items in the diet. A large number of important foods now habitually depended upon by quail were not originally native to California.

Heavy grazing results in an inferior type of quail food in addition to causing an actual food shortage.

Trees and shrubs constitute a relatively unimportant source of food for quail, and their fruits are inferior to weed seed in nutritive quality. Galls are eaten in considerable numbers.

Green leaf fragments comprise an extremely important food item for quail and when obtainable render the birds independent of free water. The seasonal fluctuation in consumption of such material runs from 1.6 per cent of the total food for October, to 85.49 per cent in April-May. Animal food, chiefly ants, is unimportant (.38 per cent of total) in the diet of adult quail, although it figures more prominently in the food of the young.

Feeding is carried on with some vigor in the early morning and then intermittently until about 4 p.m. After this hour it increases and reaches a climax of last-minute gorging just before the birds fly up to roost. During the breeding season, as a result of sentry duty by the male and incubation by the female, this schedule is largely upset.

The distance traveled by a quail covey for food each day is slight as long as food holds out; with the decrease in available food the distance traveled per day increases. Feeding mannerisms such as scratching and jumping for food are described.

Adult quail eat about 24 grams of food per day (14.3 per cent of their own weight), which amounts to 11310.7 cc. (.321 bushel; 10.27 qts.) per year. Considerable preference is exercised by quail as to the food eaten. Some plant families furnishing abundant seed are avoided entirely; the members of some of these families are strong-scented and perhaps distasteful; possibly others produce toxic effects.

New foods, especially seeds of large size, are usually rejected at first, although they may be accepted later as a result of a more or less protracted learning process.

In the case of seeds which are picked up singly, the upper limit of size eaten by California quail is about $\frac{1}{8}$cc.; the lower limit is about

1/1430 cc. Certain seeds below this minimum of size are eaten in large quantities while still inclosed in their fruit walls. Grit particles are eaten less abundantly when hard seeds form a large percentage of the food. Very minute grit particles are probably ingested accidentally.

WATER REQUIREMENTS

Free water is not required during the rainy season because it is furnished by the succulent green vegetation. When the green vegetation disappears, however, water must be obtained from pools, springs, or similar sources.

ECOLOGICAL REQUIREMENTS

Food must be present in adequate quantity within about fifty feet of cover. Cover is of relatively little use unless well interspersed with food, and it must include trees or dense bushes for roosting.

The California quail is limited topographically to the lower altitudes, those below 4000 to 8500 feet, possibly because of its inability to withstand the rigors of winter above these heights. Geographically it is limited on the west by the Pacific Ocean; on the east by the desert regions, where the water supply is inadequate to meet its needs. To the north it is limited in its distribution by the regions of heavy snowfall lying north of Klamath Lake in southern Oregon. Southward it extends to the extreme tip of the Lower California peninsula. Within its range it is a highly successful species because of its ability to maintain itself in regions differing widely as to food and cover types, seasonal rainfall, and temperature range.

EFFECT OF HUMAN ACTIVITIES

Hunting is only one of several important factors in quail decrease. It will be possible to maintain this sport on an anywhere nearly satisfactory plane in the future only by the observance of a system of game management.

Primitive farming methods in vogue during the early days of settlement were somewhat favorable to quail, but the modern system of "clean farming" has greatly reduced their numbers in certain areas. The exclusive use by man of water sources has brought about the virtual extinction of quail coveys in parts of the arid southwest. Irrigation may be locally favorable to quail, but since it is usually obtained at the expense of surface or subsurface water supplies in other regions, the net effect is detrimental.

Overgrazing is one of the most important causes of quail decrease on many range lands because of the resulting destruction of available food, and possibly because of the depletion of the mineral supply.

Predator control as practiced by private individuals has done more harm than good to quail; as practiced by government agencies it has been largely neutral in results as far as quail are concerned. Rodent control, when involving the use of thallium, has been destructive to this species.

Lumbering has tended to increase the numbers of quail by creating more "edge" environment. Fire control has probably had an unfavorable influence on an average by promoting the growth of impenetrable stands of tall brush, with the consequent choking out of food plants.

Roadways have in some cases furnished food and shelter not otherwise available, but their net effect has been distinctly harmful because they have enabled hunters to reach the most remote strongholds of the birds.

"Protection" has consisted of (1) laws, which have reached their highest development short of a continuous closed season; (2) predator control, largely futile as so far practiced; (3) the establishment of refuges, which, although representing a step in the right direction, have realized only a fraction of their potentialities because of the lack of a system of game management.

CALLS

The calls of quail are varied but the significance of a given call is rather constant; ten distinct types are described.

SOCIAL ORGANIZATION

The California quail is strongly gregarious; many of the reactions of the birds are coöperative, although instinctive. The instinct to imitate other quail is present from the first, and aids the inexperienced young in acquiring the wariness of the adults; it continues to serve as the basis for mass action throughout life.

Leadership within the flock is determined by chance. The larger the flock, the greater the number of potential leaders, which tends to prevent the permanent association of large aggregations of quail.

Sentry duty is performed by the adult male, and by him alone, from the time incubation commences until several weeks after the young have attained nearly full size and the family group has merged with other groups to form a covey in late autumn.

COVEY FORMATION AND RANGE

Coveys which have been reduced by enemies to less than ten birds usually unite with other coveys, so that in a given locality covey *size* is maintained, even though the number of coveys dwindles. Splitting, recombining, and interchanging of individuals readily occur among coveys whose ranges intersect or adjoin, rendering the chances of inbreeding remote.

The distance traveled daily by a covey varies from about 100 feet to about a quarter of a mile, depending upon the availability of food. No definite route is taken, the flock moving by impulse. During the reproductive season the range of the individual pairs is even more circumscribed.

Although the individual members of a covey may scatter widely during the breeding season, often to join some other covey in the fall, the covey as such usually remains permanent since its size, and its location is governed by the available food and shelter rather than by the fortuitous presence of any given individual.

COURTSHIP BEHAVIOR

The pugnacious stage of the males occurs in early spring before the covey has split up. Successful males attach themselves to their prospective mates and keep all other males at a distance.

Following pairing an impulse to wander considerable distances in search of a nest site results in the gradual dissolution of the covey. Male birds which have been unsuccessful in securing mates set up territory and give the *cow!* note, which means announcement that they are ready to pair. Successful males are silent and lose most of their pugnacity.

NESTING HABITS

No male quail were observed to share in the function of incubation. The female is guarded by the male during her recess periods away from the nest. No indication was observed of a pair raising two broods in a season.

CARE OF YOUNG

The small young, which are highly susceptible to chilling, are brooded on the ground by the female from about 4.30 p.m. until about 9.00 of the following morning, or even much later if the day is cold or damp. The solicitude displayed by the parents for their young, although well developed, is instinctive and unreasoned; it is expressed largely by vocal warning or encouragement, and by active defense against various enemies, but does not extend to physical aid of the young if they are for any reason unable to keep up with the family group. Greater solicitude is shown by the male than by the female.

GROWTH AND BEHAVIOR OF YOUNG

Behavior at time of hatching, initial fear and feeding reactions, play activities, voice development, and weight increase are described. Wariness is learned from the parents by imitation of their behavior; however, the process is only gradual, so that many young perish as a result of inexperience. Birds of the year may be distinguished until their second fall molt from adults by the presence of mottled primary coverts.

GENERAL BEHAVIOR AND MISCELLANEOUS HABITS OF QUAIL

Roosting behavior is described. Trees or tall bushes with dense foliage are preferred as roosting sites, but in certain semidesert regions where such vegetation is largely absent, the birds are forced to roost in low, open brush, which renders them more than usually vulnerable to owls. Instances of ground roosting are rare. Power of vision at night is poor. The hour of roosting and of awakening is determined within remarkably close limits by light intensity rather than by an absolute time unit; accordingly, the duration of roosting varies from 8 hours 18 minutes in midsummer to 13 hours 33 minutes in midwinter.

The warm hours of the forenoon and early afternoon are usually spent in resting or dust bathing.

The wariness of quail results from an innate timidity and nervousness, together with a retentive memory for fear experiences, rather than from any unusual mental development.

Hearing is relatively unimportant as a means of detecting danger.

MORTALITY

Nest failures in the region studied amounted to about 60 per cent of all nests, irrespective of whether they represented first, second, or third attempts. Mortality of young during the first week of life appeared to be approximately 21.6 per cent; for the first month probably about 39.6 per cent.

Stormy weather is usually an unimportant cause of mortality, but extreme drought, by curtailing or entirely preventing breeding, is occasionally serious in its results.

Natural enemies constitute a slow drain on quail, but mortality from this cause is not serious so long as the food supply lasts. Cooper and sharp-shinned hawks are the most important enemies of quail; horned owls prey on quail to a significant extent only in localities where roosting cover is inadequate; jays do no significant damage where cover is adequate; the precise status of snakes as enemies of quail is unknown, but certain species may possibly be important locally; the status of various other predators, none of which is important as an enemy of quail, is discussed.

Accidents, chiefly collisions with objects while in flight, result in a considerable number of deaths to quail.

Disease was not observed in the Santa Cruz Mountain area, but an outbreak the cause of which could not be ascertained was detected in Oakland, California.

POPULATION STUDIES

In a restricted area representing nearly ideal environmental conditions the number of quail varied from 1.1 to 3.9 per acre, according to the season of the year. On 60 acres, 64 per cent of a total of 31 potential pairs were ultimately successful in raising broods.

A shootable surplus of approximately 19 per cent apparently existed in the population studied.

On the area covered by this study, which was not shot over, 26.8 per cent of the birds were alive at the end of the first year, 7.2 per cent at the end of the second, 2.0 per cent at the end of the third, .5 per cent at the end of the fourth.

Males outnumbered females in the ratio of 53.2 to 46.8.

WEIGHT CHANGES

Maximum weight in the male occurs during the winter and early spring months, while marked decrease takes place during the breeding season as a result of nervous excitement and the irregular feeding habits imposed by sentry duty. The female is relieved of strenuous courtship activity and sentry duty, and is at this period heavier than the male, showing no loss of weight until after the young have hatched.

Neither sex regains lost weight until after the completion of the fall molt. Immature birds show similar weight fluctuations, but do not attain full adult weight until the beginning of the second year.

An average loss in weight of 5.86 per cent takes place between the time when quail go to roost with full crops and the time of awakening with empty crops in the morning.

California quail decrease in size from the northern part of their range southward to the southern extremity of Lower California, in accordance with "Bergmann's Law."

PLUMAGES

Plumage changes, including those of the young, are described; birds of the year can be distinguished from full adults until the second summer, by the mottling of the first six (proximal) upper primary coverts which are vestiges of the juvenal plumage.

CALIFORNIA FISH AND GAME

A publication devoted to the conservation of wild life and published quarterly by the California Division of Fish and Game.

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All material for publication should be sent to J. O. Snyder, Division of Fish and Game, 450 McAllister Street, San Francisco, California.

Vol. 21 JULY, 1935 No. 3

EDITORIAL

This and the following number of CALIFORNIA FISH AND GAME will be mostly devoted to two parts of a paper by E. Lowell Sumner, Jr., entitled "A Life History Study of the California Quail, with Recommendations for its Conservation and Management." The paper is a final report of an investigation carried on by Mr. Sumner, under the general supervision of Dr. Joseph Grinnell of the Museum of Vertebrate Zoology, Berkeley, who has also edited the manuscript.—*J. O. S.*

REORGANIZATION OF THE DIVISION OF FISH AND GAME

The Fish and Game Commission, at its meeting of July 6, 1935, approved the following reorganization plan of the Division of Fish and Game.

The reorganization was done to create a smoother working program and this was brought about by a combination of the functions which referred to fish, and a separate unit was made of those functions which referred to game.

The Bureau of Fish Culture name was changed to that of the Bureau of Fish Conservation, and the scope of its work will cover fresh and salt water fishes. The reasons for this change in name are: First, to have the name of the bureau more clearly describe its activities, and secondly, it is expected that the scope of this bureau's work will be extended to cover all fish on the sporting list, both fresh water and salt water. Dr. J. O. Snyder will remain in charge of this bureau.

The Bureau of Game Conservation was formed to include the bureau formerly known as Game Refuges and that formerly known as Game Propagation. It will be composed of two units—one dealing with birds and one dealing with mammals. It was thought advisable to have the Bureau of Game Propagation represented in the main office of the division where inquiries might be answered without having to refer them to the Game Farm at Yountville, as was formerly the case. J. S. Hunter will be in charge of the new bureau, and August Bade will serve under the title of Superintendent of State Game Farms.

The name of the Bureau of Education and Research has been changed to the Bureau of Research and Engineering. All research work of the division will be handled by this bureau and other bureau

heads will act as an advisory council. This bureau is to be headed by Herbert C. Davis.

The positions in the Bureau of Patrol have been reorganized as follows: There are to be six civil service ratings—Chief, Inspector, Captain, Sergeant, Warden and Deputy Warden. The examination for Deputy Warden is to be open to the public and will serve as an apprentice grade. The Deputy Warden will serve an apprenticeship in the various bureaus, thoroughly learning the scope of work in the division and to what phase of the work he is best suited. After a fixed period of years' service as Deputy Warden, promotion can be obtained by taking and passing the examination for Warden, which examination, and subsequent promotional examinations will be open only after the successive probation periods have been successfully passed.

It is sincerely hoped that under this reorganization, new interest and confidence will be instilled in the personnel of the division and that the work will be efficiently handled.—Herbert C. Davis.

FORECAST FOR THE 1935–1936 SARDINE SEASON

This report comprises the third prediction of the abundance and sizes of sardines to be expected in the immediately succeeding sardine season. The results of the first forecast, which were very satisfactory, were discussed when the second prediction was published in 1934.* The success of the second prediction is indicated at the close of this article.

PREDICTIONS FOR THE 1935-1936 SARDINE SEASON

The outlook for the coming sardine season is not promising. The fishery should draw chiefly from three super-abundant year classes, which entered the fishery in 1929, 1930, and 1933, respectively. The groups which entered in 1929 and 1930 should furnish the main support for the winter fishery and the one which entered in 1933 should supply the major portion of the fall fishery, but due to the intensive fishing from 1933 to 1935, especially in the fall months, the superabundance of these three groups has been wiped out. The groups entering in 1929 and 1930 are now below normal in abundance and the 1933 group is reduced to normal or perhaps below. We have no indications that a new superabundant group will enter the fishery in the fall of 1935.

All of the year classes from which the 1935–1936 fishery will draw are, therefore, no more abundant than average and many of them are below average. This means that the entire sardine population is seriously reduced in numbers. An absolute measure of the extent of this reduction is not available and we can not state definitely how scarce sardines will be in the coming season. Schools may be only moderately difficult to locate and they may be extremely so. This will hold for both the fall and winter fisheries.

* The 1934–1935 sardine season, Calif. Fish and Game, vol. 20, pp. 298–300, 1934.

For each locality the prediction is as follows:

FALL FISHERY

San Francisco and Monterey (August-November).

Sardines will be less abundant than in 1934–1935, and the sizes will be mixed. San Francisco fish will be somewhat larger than those taken at Monterey. The sizes at Monterey will vary from $8\frac{1}{2}$ to 11 inches, total length, and approximately one-half will be from $9\frac{1}{2}$ to $10\frac{1}{2}$ inches.

San Pedro (November-December).

In this region also, sardines will be less abundant than in the fall of 1934–1935, and the sizes will be mixed. The range will be from $8\frac{1}{2}$ to 11 inches, total length, and about half will be between 9 and 10 inches.

WINTER FISHERY

All Localities.

During the winter months sardines will be less abundant than in former winters and a mixture of sizes will be found in the fishery. Fish as small as $8\frac{1}{2}$ and as large as 13 inches will be taken, but probably the majority will be between 10 and $11\frac{1}{2}$ inches.

SUCCESS OF THE 1934-1935 PREDICTIONS

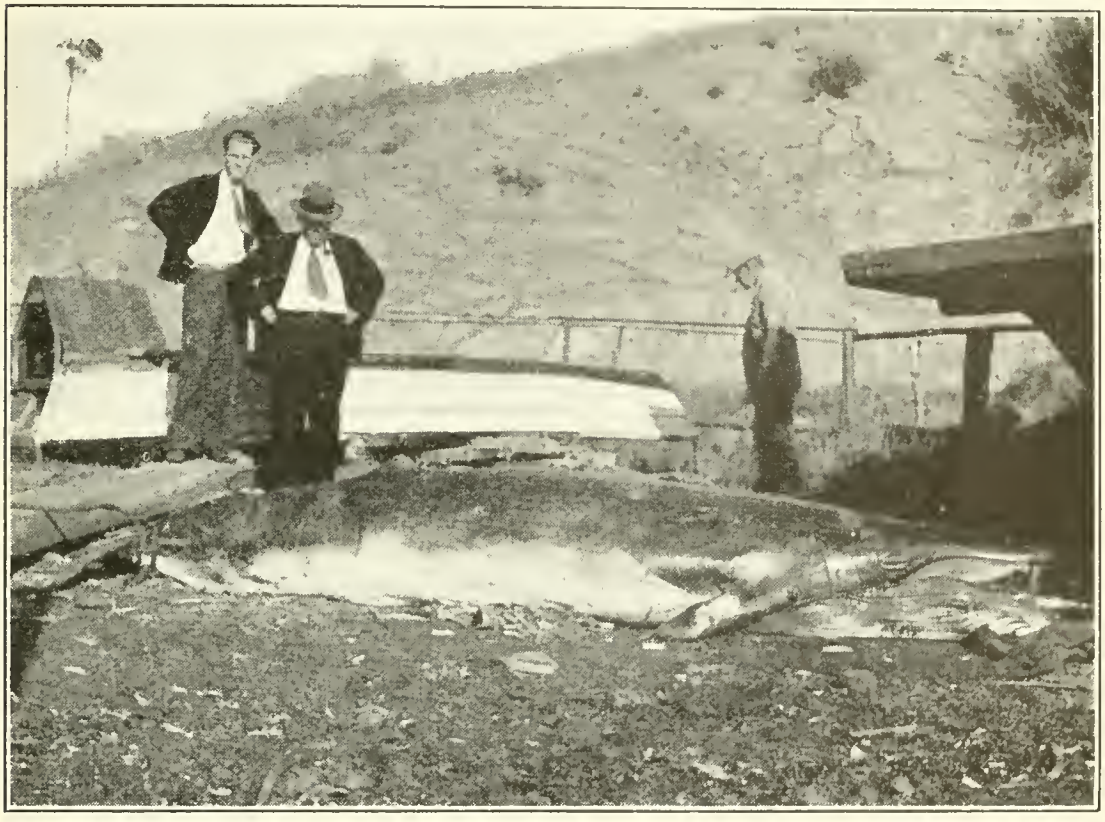
To facilitate comparisons, the predictions which were made for 1934–1935 are listed on the left and the actual occurrences on the right of the following tabulation:

Prediction	Actual Occurrence
SIZES OF SARDINES	
Fall Fishery	
Average would be between 9½ and 10 inches, total length.	Monterey fish averaged 10.0 inches. San Pedro fish averaged 9.9 inches.
Winter Fishery	
About 25 per cent would approximate 10 inches, total length, and the majority would be 11 inches or greater.	For the combined Monterey and San Pedro fisheries, 20.3 per cent were between 9½ and 10½ inches, and 59.6 per cent were 11 inches or greater.
ABUNDANCE OF SARDINES	
Fall Fishery	
Quite abundant, and boats would not have difficulty in making catches.	Sardines were satisfactorily abundant at all ports, but perhaps less so at San Pedro than at Monterey.
Winter Fishery	
Fish would be no more, and perhaps less, abunant than in the winter of 1933–1934.	The winter fish appeared at Monterey in December and at San Pedro in February. During each of these months at each port the winter sardines were numerous and the fishermen made their catches with ease. At Monterey in January and February and at San Pedro in March, winter fish were scaree and on many nights much of the fleet failed to make any eatch or brought in only a small tonnage.

The predictions for the sizes of sardines and the abundance of fish in the 1934–1935 season proved to be accurate. For the coming season, 1935–1936, all available information points to no increase in abundance and to the probability of an increasing and possible decided scarcity. Our predictions refer to abundance or scarcity of fish in the ocean but not to variations in the amount of total catch.—*Contribution No. 149 from the California State Fisheries Laboratory, May, 1935.*

WHALE CAUGHT IN CARQUINEZ STRAITS

A whale of a species not previously known to fishermen in the Carquinez Straits was caught in a net set for salmon off Dillon's Point, near Benicia, California, on May 26, 1935.



Humpback whale caught in the Carquinez Straits. Photograph by E. A. Stoner, May 27, 1935.

The presence of a mammal of this kind in these waters, especially at a season when the water is practically fresh, is considered rather surprising. Assumed evidence of the freshness of the water is the fact that the California-Hawaii Sugar Refinery was still taking on water in their water barge near this point.

The whale was identified by the writer as the Pacific Humpback (*Megaptera versabilis*) using Paul Bonnot's "The Whales of California," published in the July, 1929, CALIFORNIA FISH AND GAME as a guide. It was thirteen feet in length and conservatively estimated as weighing fifteen hundred pounds.

Lawrence Gando and George Marinos, who brought the specimen to the shore at Capello's Beach, Benicia, reported a four-hour fight with the animal before finally subduing it with the aid of an axe when it had finally become worn out in the struggle. The net was badly torn, and the boat many times threatened during the battle to get it to shore. Mr. Joseph Capello estimated that five hundred people came to his wharf to view the stranger.

The only other whale reported as having been seen in these straits was a killer whale brought in about five years ago.—*Emerson A. Stoner, Benicia, California.*

A LARGE NORTHERN HALIBUT IN MONTEREY

On the morning of May 3, 1935, a northern halibut (*Hippoglossus hippoglossus*), weighing 89 pounds and measuring 5 feet 3 inches from tip of snout to tip of tail, was caught in 30 fathoms of water, two miles north of the town of Monterey. The specimen was caught on a rockfish long line by commercial fishermen, M. Silveria and B. Silveria, fishing from a skiff. From available records, this is the largest specimen of northern halibut taken so far south.

The northern halibut (right halibut or genuine halibut as it is sometimes called) is a north Pacific form, ranging as far north as Bering Sea. Only occasional specimens are taken as far south as Monterey Bay. To the northward, some specimens attain a weight of 500 pounds.

The California halibut (*Paralichthys californicus*), sometimes called chicken halibut or southern halibut, ranges from San Francisco southward to the Gulf of California, and rarely reaches a weight of 60 pounds.

In California, the largest commercial landings of northern halibut are at the port of Eureka, and the largest landings of California halibut are at the ports of Los Angeles, Santa Barbara and San Luis Obispo. The annual poundage of California halibut landed is usually two to three times that of the northern halibut.—*J. B. Phillips, California State Fisheries Laboratory, May 14, 1935.*

NEW MACKEREL CANNERIES

In view of the rapidly expanding market for canned mackerel, it is not surprising that new canneries are being built in southern California.

With the 1934 pack of 1,230,000 standard cases completely sold out, practically every fish cannery from Monterey to San Diego is at present packing mackerel. Six plants at Monterey, seven at San Pedro and four at San Diego are canning all the mackerel they can obtain. Two additional San Pedro canneries are preparing to recommence activities after five years' idleness as far as mackerel are concerned.

In addition to the activity of the established plants, there are three new plants either ready or nearly ready to start mackerel packing. All three are located at Newport. Two of these are completely rebuilt fruit and vegetable canneries. Both of them have already packed on an experimental scale and are ready to pack in earnest as soon as mackerel appear in abundance. The third cannery is new in every respect. At the present time the building itself is not quite completed, so production can not commence before late summer.—*Richard S. Croker, California State Fisheries Laboratory, May 17, 1935.*

A NEW NET DEVELOPMENT

During the past winter (1934–1935) a somewhat new type of net, or rather a new adaptation of an old type, has been developed at San Pedro. So far, but one boat has used this net.

The net is a miniature purse seine made of tanned webbing. It is 100 fathoms long, 10 fathoms deep, of 3-inch mesh (stretched measure). It can be handled and hauled by four or five men. This rapid-action net is used in shallow water in the small open spaces between kelp beds. The fish most often caught is the halfmoon (*Medialuna californiensis*) which is in fairly good demand at the San Pedro markets. The halfmoon can be observed in small schools swimming leisurely near the surface, so the small net can be laid around them without much trouble. The largest single haul so far made was somewhat over one ton.—*Richard S. Croker, California State Fisheries Laboratory, May 17, 1935.*

INCREASED UTILIZATION OF FISH LIVERS

The value of various fish liver oils as sources of vitamins A and D has recently been realized, following the research work of several commercial, university and government laboratories.

For years, cod liver oil has been recognized as beneficial in the treatment of various deficiency diseases. Several years ago the liver oil of the halibut was found to be much more potent than the cod liver oil. More recently it has been found that the livers of many other species of fish produced oils relatively high in vitamin content.

At the present time several of the large medicinal firms have buyers in California, purchasing fish livers from fish markets and canneries. They have found that the livers from some species are worthless, yielding very little oil and being poor in vitamin content. Other species yield very good quantities, relatively high in either vitamin A or D content. The white sea-bass, barracuda, swordfish, totuava, mackerel, bonito, tuna, and several other species have livers worth saving. The marketmen have found that cleaning costs can be defrayed by saving and selling the livers of the fish they handle. Tuna canners realize a considerable saving in the cost of producing canned tuna by selling the livers. The utilization of mackerel livers has resulted in an increase in employment in the canneries, and at the same time the canners have found that the cost of producing a case of mackerel has been reduced 5 to 10 cents since the practice started. As production costs in general have risen notably the last few months, the sale of tuna and mackerel livers often marks the difference between selling canned fish at a profit and selling at cost. The fish cleaners separate the livers from the offal and place them in five-gallon cans which have a capacity of 40 pounds. The cans are packed in ice and are picked up daily by the buyers. During the past two years the liver cans have become a familiar sight in practically every market and cannery in California.—*Richard S. Croker, California State Fisheries Laboratory, May 18, 1935.*

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NOTES FROM THE STATE FISHERIES LABORATORY

The tagging of tuna was begun on an experimental scale in May, 1934, and during the summer something over 100 fish were marked on the preoperele with a metal strap tag. The tag carries a brightly colored celluloid disc, so as to be readily recognized by fishermen. The first tag to be returned was by a San Diego fisherman on February 1, 1935.

Much may be learned about the behavior of sardines and mackerel by tagging, but with these two fishes it is probable that an internal tag carried in the body cavity would be more successful, especially so in the case of sardines where large numbers are dumped into reduction plants without being handled as individual fish. If internal tags are used the tags will have to be recovered in the reduction plants either by some mechanical device or by the use of magnets which will pick the metal tag from the fish meal. Initial experiments in the use of such tags are being conducted at the laboratory.

H. C. Godsil and Richard S. Croker made a trip on the patrol boat *Bluefin* to Turtle Bay, Mexico, on January 29—February 13, 1935, for the purpose of tagging tuna and securing samples of the bait sizes of sardines from that area.

On April 21, 1935, H. C. Godsil sailed on the fishing boat *Reliance* for Mexican waters to carry on tuna studies, including the tagging of yellowfin tuna.

During April, 1935, D. H. Fry, Jr., made a trip on the *Bluefin* to Magdalena Bay, Mexico, to scout for adult mackerel during the time they are so scarce in the waters of southern California. Adults were not found in any quantity in that region, and the eggs and larval stages of the mackerel were almost absent from Mexican waters at that time of year.

During the spring of 1935, several trips by different members of the staff were made to San Diego in order to determine the relative abundance of the sardine quarter-oil sizes that may be expected to enter the San Pedro commercial catch in the fall of 1935. This next entering age-class of sardines appears to be below normal in abundance, so we can not expect that our present sardine supply will be heavily recruited in the fall.

During April, L. A. Walford, a former member of our staff, returned on the yacht *Haida* from a two months' cruise in Mexican waters where he collected specimens and notes for issuing a book on some of the sport fishes of that area. An artist accompanying the expedition prepared color paintings of the more important sport fishes. We look forward with great interest to the appearance of this volume.

Through the summer of 1935, the statistical clerks under the direction of Geraldine Conner were unusually busy with special reports in addition to the routine work of tabulating current fish catch data. Many of these special reports were for use at Sacramento during the session of the State Legislature and others were for use of the laboratory research staff.—*W. L. S., May 16, 1935.*

SIZES OF SARDINES TAKEN BY GEAR AND AREA

The California State Fisheries Laboratory recently issued Fish Bulletin 43, "The sizes of California sardines caught by the different fishing gear and in the different localities of the Monterey and San Pedro regions," comprising two reports by J. B. Phillips and G. H. Clark. The authors present the results of an investigation made to determine whether or not the system of sardine sampling as carried on in the past is still adequate since changes have occurred in the fishery. The results are of importance to the industry because they show that lampara, purse seine and ring nets all take the same sizes of fish, that these sizes comprise the sardines available to the fishermen, and that no type of gear exhibits size selection differing from any other type. Of greater importance to the industry is the evidence indicating that large fish first appear each winter to the north of Monterey and gradually become disseminated southward throughout the entire Monterey region, whereas in the San Pedro region no consistent distribution of differential sizes within the region is evident. The results are of value to the sardine investigation because of the demonstration of the continual reliability of our sardine sampling system and the furnishing of additional evidence of a southward movement of sardines along the California coast during the winter months.—*G. H. C.*

SEIZURES OF FISH AND GAME

January, February, March, 1935

Game:	
Deer	10
Deer meat, pounds	2,809
Deer hides	2
Ducks, geese, mudhens	432
Doves	1
Non-game birds	24
Pheasants	9
Pigeons	1
Quail	26
Rabbits	13
Tree squirrels	1
Bird nets	3
Guns	10
Fish:	
Abalones, pounds	2,016
Bass, striped	27
Crappie, sunfish	22
Catfish, pounds	70
Clams	2,581
Halibut, pounds	800
Lobsters	67
Trout	17
Trout, steelhead, pounds	4,075
Traps, fish	1

GAME CASES

January, February, March, 1935

Offense	Number arrests	Fines imposed	Jail sentences (days)
Deer; closed season; killing of does	91	$1,962 00	1,441
Ducks; closed season; selling of	59	2,860 00	31
Doves; closed season	2	25 00	
Hunting, no license	41	400 00	217½
Firearms in refuge	3	50 00	
Nongame birds; killing of	16	500 00	
Pheasants; closed season	6	275 00	
Pigeons; closed season	2	25 00	
Quail; closed season	5	225 00	
Rabbits; closed season	1	25 00	
Shorebirds; killing of	4	100 00	
Spotlight hunting	3	225 00	
Trespassing on posted grounds	2	2 00	
Tree squirrels; killing of	1	50 00	
Shooting from highway	3	10 00	
Bird nets; illegal	1	15 00	
Miscellaneous game cases	4	15 00	
Totals	244	$6,764 00	1,689½

FISH CASES

January, February, March, 1935

Offense	Number arrests	Fines imposed	Jail sentences (days)
Angling; no license	19	$295 00	47½
Abalones; small; drying of	28	397 50	162½
Bass, striped; overlimit	1	100 00	
Commercial fishing; no license	41	45 00	54
Clams; over limit; small	79	1,275 00	134½
Catfish; selling small	1	25 00	
Cockles; over limit	4	75 00	12½
Crappie; closed season	5	60 00	
Lobsters; small	3		
Night fishing	2	50 00	
Pollution of streams	9	150 00	
Spears; illegal use of	7	160 00	
Salmon; spearing of; closed season	2	50 00	
Trout; closed season; spearing of	14	155 00	55
Nets and set lines; illegal	4	150 00	120
Miscellaneous fish cases	7	50 00	12½
Totals	226	$3,037 50	598½

STATEMENT OF EXPENDITURES

For the Period July 1, 1934, to March 31, 1935, of the Eighty-sixth Fiscal Year

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Administration:					
Executive	$5,504 77				$5,504 77
Clerical and office	4,140 00	$693 77	$158 19	$49 02	5,040 98
Printing, Fish and Game Magazine		779 48			779 48
Printing, general		2,416 83			2,416 83
Automobiles		353 40	378 35		731 75
Traveling			1,872 99		1,872 99
Postage			3,059 26		3,059 26
Telephone and telegraph			2,760 06		2,760 06
Freight, cartage and express			550 32		550 32
Rent			9,824 18		9,824 18
Accident and death claims			5,261 62		5,261 62
Accounting pro rata	3,991 13				3,991 13
Legal			1,942 75	16 00	1,958 75
Premiums on bonds			50 00		50 00
Publicity			954 37		954 37
Total Administration	$13,635 90	$4,243 48	$26,812 09	$65 02	$44,756 49
Bureau Education and Research:					
Clerical and office	$1,440 00	$9 90	$28 62		$1,478 52
Automobiles		422 32	101 47		523 79
Traveling			1,431 38		1,431 38
Photography		11 84	52 39		64 23
Library	$10 00	14 94	52 07	$109 33	986 34
Research	2,400 00	87 42	38 90	12 30	2,538 62
Publicity	1,381 84		61 38		1,443 22
Total Bureau Education and Research	$6,031 84	$546 42	$1,766 21	$121 63	$8,466 10
Bureau Patrol and Law Enforcement:					
Chief and assistants	$8,325 00				$8,325 00
Clerical and office	2,385 00	$28 20	$62 75	$30 00	2,505 95
Automobiles		19,792 17	9,745 03	5,583 65	35,120 85
Traveling			31,514 47		31,514 47
Postage			457 11		457 11
Telephone and telegraph			1,286 55		1,286 55
Freight, cartage and express			6 45		6 45
Rent			547 71		547 71
Captains and wardens	138,562 42	716 99	891 43	26 51	140,197 35
Launches		1,328 17	763 67	310 27	2,402 11
Fish planting	3,465 00	492 82	1,759 61	12 19	5,729 62
Premiums on bonds			232 50		232 50
Cooks	1,016 12				1,016 12
Commercial fisheries patrol:					
Chief	2,070 00				2,070 00
Captains and wardens	10,117 10	6 60	8 00	12 52	10,144 22
Launches	8,756 63	3,162 69	2,180 28	323 16	14,422 76
Fish cannery inspectors, seasonal	8,041 32				8,041 32
Traveling			3,937 83		3,937 83
Rent			658 00		658 00
Automobiles		538 57	410 42		948 99
Temporary help	237 92				237 92
Total Bureau Patrol and Law Enforcement	$182,976 51	$26,066 21	$54,461 81	$6,298 30	$269,802 83
Bureau Commercial Fisheries:					
Chief and assistants	$10,215 00				$10,215 00
Clerical and office	7,200 00	$58 91	$74 45	$97 83	7,431 19
Automobiles		393 10	229 88		622 98
Traveling			4,098 21		4,098 21
Telephone and telegraph			474 83		474 83
Freight, cartage and express			76 40		76 40
Rent			106 48		106 48
Heat, light, water and power			273 23		273 23
Research	1,710 00	12 72		105 93	1,828 65
Laboratory	17,280 00	490 36	514 74	376 32	18,661 42
Hydro-Biological Survey—Monterey Bay			450 00		450 00
Temporary help	75 87				75 87
Statistics		487 66	1,552 50	29 42	2,069 58
Total Bureau Commercial Fisheries	$36,480 87	$1,442 75	$7,850 72	$609 50	$46,383 84
Less Indirect Abatements:					
Deer tag regulation			$328 60		$328 60
Total Bureau Commercial Fisheries Adjusted	$36,480 87	$1,442 75	$7,522 12	$609 50	$46,055 24

STATEMENT OF EXPENDITURES—Continued

For the Period July 1, 1934, to March 31, 1935, of the Eighty-sixth Fiscal Year

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Bureau Fish Culture:					
Chief and assistants	$5,445 00	$2 89	$5 00		$5,452 89
Clerical and office	3,968 39	17 72	12 25	$73 82	4,072 18
Automobiles		5,125 88	2,499 30	6,346 48	13,971 66
Traveling			5,978 56		5,978 56
Postage			160 01		160 01
Telephone and telegraph			777 43		777 43
Freight, cartage and express			548 59		548 59
Rent			2,564 00		2,564 00
Heat, light and power			1,204 91		1,204 91
Hatcheries	$1,231 17	38,957 28	660 25	1,009 34	121,858 04
Fish cars	2,655 00	231 81	2,081 89		4,968 70
Blue printing			51 40		51 40
Cooperative research	1,558 39	545 52	697 56	224 91	3,026 38
Temporary help	809 00				809 00
Fish hatchery assistant, seasonal	14,619 49				14,619 49
Hydraulic engineering	1,800 00	17 76	653 76	4 46	2,475 98
Special field	5,859 05	52 46	9 40	13 72	5,934 63
Fish rescue:					
Miscellaneous supplies		47 18		5 98	53 16
Heavy truck mileage			336 51		336 51
Travel			1,211 88		1,211 88
Rent and water service			59 00		59 00
Motorized equipment		124 82	26 10	551 25	702 17
Chief and assistants	1,800 00		235 53		2,035 53
Total Bureau Fish Culture	$119,745 49	$45,123 32	$19,773 33	$8,229 96	$192,872 10
Bureau Game Propagation:					
Chief and assistants	$4,095 00				$4,095 00
Clerical and office	630 00				630 00
Automobiles		$800 98	$260 50	$963 66	2,025 14
Traveling			1,413 95		1,413 95
Postage			11 04		11 04
Telephone and telegraph			141 55		141 55
Freight, cartage and express			5 36		5 36
Heat, light, water and power			1,226 52		1,226 52
Maintenance	8,703 00	6,533 48	181 70	4 55	15,422 73
Temporary help	33 55				33 55
Refuge maintenance	1,269 00				1,269 00
Quail trapping and expansion of quail program	3,465 00	788 78	1,981 38	10 55	6,245 71
Purchase of quail and pheasants		4,134 60			4,134 60
Total Bureau Game Propagation	$18,195 55	$12,257 84	$5,222 00	$978 76	$36,654 15
Bureau Game Refuges:					
Chief and assistants	$6,374 97				$6,374 97
Clerical and office	1,440 00	$11 83	$11 50		1,463 33
Automobiles		392 87	229 67		622 54
Traveling			3,133 79		3,133 79
Freight, cartage and express			4 88		4 88
Blue printing			4 18		4 18
Research			328 60		328 60
Lion hunters	4,077 00				4,077 00
Refuge posting	675 00				675 00
Predatory animal control			4,890 00		4,890 00
Refuge maintenance	6,115 32	1,482 16	1,016 93	$115 51	8,729 92
Predatory animal hunters and trappers, seasonal	4,500 00				4,500 00
Temporary help, seasonal	2,820 50				2,820 50
Total Bureau Game Refuges	$26,002 79	$1,886 86	$9,619 55	$115 51	$37,624 71
Bureau Licenses:					
Clerical and office	$9,855 00	$83 29	$14 45	$93 79	$10,046 53
Printing, licenses and applications		1,360 28			1,360 28
Traveling			413 62		413 62
Postage			893 58		893 58
Freight, cartage and express			188 58		188 58
Premiums on bonds			1,063 25		1,063 25
Identification license buttons		5,191 00			5,191 00
Total Bureau Licenses	$9,855 00	$6,624 57	$2,573 48	$93 79	$19,156 84
Total 86th fiscal year expense paid from support appropriations	$412,923 95	$98,201 45	$127,750 59	$16,512 47	$655,388 46
Prior year expense for support, 85th fiscal year					17,423 20
Total 85th and 86th fiscal year expense paid from support appropriations					$672,811 66

STATEMENT OF EXPENDITURES—Continued

For the Period July 1, 1934, to March 31, 1935, of the Eighty-sixth Fiscal Year

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Special items:					
86th fiscal year—					
License commissions			$33,312 54		$33,312 54
Construction Russian River Jetties, Chap. 989-33			419 46		419 46
California Code Commission for expenses, Chap. 645-33			3,198 21		3,198 21
Electro Metal Co.'s claim, Chap. 599-31			18,750 00		18,750 00
Total 86th fiscal year			$55,680 21		$55,680 21
85th fiscal year:					
License commissions				$315 65	
Construction Russian River Jetties, Chap. 989-33				30 00	
Total 85th fiscal year					345 65
Total special items					$56,025 86
Permanent improvements:					
Construction, improvements and equipment:					
86th fiscal year	$5,172 50	$4,718 96	$7,704 28	$1,822 39	$19,418 13
85th fiscal year					46 32
Total permanent improvements					$19,464 45
Bureau of Commercial Fisheries—Chap. 825-33—Fresh fish marketing:					
86th fiscal year:					
Chief and assistants	$4,526 50				$4,526 50
Clerical and office	990 00	$192 00		$6 35	1,188 35
Printing		3,244 00			3,244 00
Automobiles		95 51	$93 72		189 23
Traveling			1,753 60		1,753 60
Postage			484 50		484 50
Telephone and telegraph			2 95		2 95
Freight, cartage and express			433 32		433 32
Rent			70 70		70 70
Exhibits		295 29	2,224 60		2,519 89
Temporary help	212 37				212 37
Pro rata fish and game administration		13 01			13 01
Total 86th fiscal year	$5,728 87	$3,839 81	$5,063 39	$6 35	$14,638 42
85th fiscal year					11 55
Total Bureau of Commercial Fisheries—Chap. 825-33—Fresh fish marketing, 85th and 86th fiscal years					$14,626 37
Contributions to retirement system					11,451 01
Total from current biennium					774,379 85
Prior biennium appropriations:					
85th fiscal year—					
Permanent improvements:					
Construction, improvements and equipment					583 19
84th fiscal year:					
Support					853 65
Total from prior biennium appropriations					270 46
Grand total proprietary group					$774,650 31

STATEMENT OF REVENUE

For the Period July 1, 1934, to March 31, 1935, of the Eighty-sixth Fiscal Year

Revenue for Fish and Game Preservation Fund, Current Year–		
License sales:		
Angling licenses, 1934	$306,498 50	
Angling licenses, 1935	8,545 50	
Commercial hunting club licenses, 1934-35	1,225 00	
Commercial hunting club operators' licenses, 1934-35	265 00	
Deer tags, 1934	108,909 00	
Fish breeders' licenses, 1934	25 00	
Fish breeders' licenses, 1935	300 00	
Fish importers' licenses, 1934	35 00	
Fish importers' licenses, 1935	75 00	
Fish packers' and wholesale shellfish dealers' licenses, 1934-35	900 00	
Game breeders' licenses, 1934	115 00	
Game breeders' licenses, 1935	737 50	
Hunting licenses, 1933-34	3,931 50	
Hunting licenses, 1934-35	205,255 34	
Kelp licenses, 1934	20 00	
Kelp licenses, 1935	20 00	
Market fishermen's licenses, 1934-35	28,790 00	
Market fishermen's licenses, 1935-36	520 00	
Trapping licenses, 1934-35	1,470 00	
Total license sales		$667,637 34
Other income:		
Court fines	$29,983 51	
Dividends California National Bank	7,418 03	
Dividends Trinity County Bank at Weaverville	71 00	
Fish packers' tax	268,548 57	
Fish tag sales	1,986 55	
Game tag sales	127 95	
Importers' contributions	230 00	
Interest on bank balances	5,009 96	
Kelp tax	67 01	
Lease of kelp beds	1,309 20	
Miscellaneous sales	3,068 11	
Publication sales	446 20	
Total other income		$318,266 09
Total Fish and Game Preservation Fund		$985,903 43
Revenue for the General Fund (part of):		
Unclaimed checks and deposits		168 15
Grand total all funds		$986,071 58

FRESH FISH IMPORTATIONS BY POINT OF ORIGIN, JANUARY, FEBRUARY AND MARCH, 1935

Compiled by the Division of Fish and Game, Bureau of Commercial Fisheries

Species	Gulf of California	West Coast Lower California	International waters south U. S. boundary (definite origin unknown)	Mexican Mainland and Central and South America	Japan	Total pounds
Barracuda		39,312				39,312
Cabrilla	6,103	3,481	19			9,603
Corbina, Mexican	59,544		150			59,694
Cultus, Pacific		394				394
Grouper		500	790			1,290
Halibut, California		183,073	21,254			204,327
Mackerel, Pacific		1,429				1,429
Rock Bass		1,862				1,862
Rockfish		70,564				70,564
Sablefish		1,832				1,832
Sardine		405				405
Sea-bass, Black	729	100,435	35,159			136,323
Sea-bass, Totuava	908,808					908,808
Sea-bass, White		649	42			691
Shark		733				733
Sheepshead		577				577
Skate		325				325
Smelt		2,011				2,011
Sole		139				139
Swordfish, Broadbill		511				511
Tuna, Albacore					581,269	581,269
Tuna, Bonito		36,939	1,768			38,707
Tuna, Skipjack		142,208	219,939	30,925	839,618	1,232,690
Tuna, Yellowfin		1,169,237	7,422,505	2,626,030		11,217,772
Whitefish		7,118				7,118
Yellowtail		659,637	46,063			705,700
Crustacean:						
Lobster, Spiny		441,776				441,776
Total pounds	975,184	2,865,147	7,747,689	2,656,955	1,420,887	15,665,862

FRESH FISH IMPORTATIONS* FROM FOREIGN COUNTRIES, FOR JANUARY, FEBRUARY AND MARCH, 1935

Compiled by the Division of Fish and Game, Bureau of Commercial Fisheries

Species	Landed in Region 70, Los Angeles	Landed in Region 80, San Diego	Total pounds
Barracuda	8,153	31,159	39,312
Cabrilla	8,748	855	9,603
Corbina, Mexican	58,849	845	59,694
Cultus, Pacific		394	394
Grouper	1,220	70	1,290
Halibut, California	56,327	148,000	204,327
Mackerel, Pacific		1,429	1,429
Rock Bass	971	891	1,862
Rockfish	10	70,554	70,564
Sablefish		1,832	1,832
Sardine		405	405
Sea-bass, Black	95,850	40,473	136,323
Sea-bass, Totuava	884,212	24,596	908,808
Sea-bass, White	132	559	691
Shark	131	602	733
Sheepshead	354	223	577
Skate		325	325
Smelt	200	1,811	2,011
Sole	75	64	139
Swordfish, Broadbill		511	511
Tuna, Albacore	581,269		581,269
Tuna, Bonito	9,992	28,715	38,707
Tuna, Skipjack	876,616	356,074	1,232,690
Tuna, Yellowfin	3,557,350	7,660,422	11,217,772
Whitefish	1,903	5,215	7,118
Yellowtail	324,582	381,118	705,700
Crustacean:			
Lobster, Spiny	51,789	389,987	441,776
Total pounds	6,518,733	9,147,129	15,665,862

* These importations are included in tables of landings.

CALIFORNIA FRESH FISH LANDINGS* FOR JANUARY, FEBRUARY AND MARCH, 1935

Compiled by the Division of Fish and Game, Bureau of Commercial Fisheries

Species	Region 10, Del Norte	Region 20, Eureka	Region 30, Sacramento	Region 40, San Francisco	Region 50, Monterey	Region 60, Santa Barbara	Region 70, Los Angeles	Region 80, San Diego	Total pounds
Anchovy				2,050	2,365		893		5,308
Barracuda						8,002	176,017	43,580	227,599
Cabezone				200	315	46			561
Cabrilla							8,748	855	9,603
Carp			47,038				5,425		52,463
Catfish			42,164						42,164
Corbina, Mexican							58,849	845	59,694
Cultus, Pacific	3,278	55,619		117,126	21,953	48	78	1,344	199,446
Eel, Moray							51		51
Flounder, Starry		7,314	150	242,319	4,365				254,148
Grouper							1,220	70	1,290
Hake				11,361			1,302		12,663
Halibut, California				3,743	12,513	66,359	196,265	193,633	472,513
Halibut, Northern	505	15,918		4,672					21,095
Hardhead			32,390						32,390
Herring, Pacific	346	6,781		537,735	10,805	82		229	555,978
Kingfish				400	72,559		152,959	1,864	227,782
Mackerel, Horse					8,476	240	192,508		201,224
Mackerel, Pacific				105	156,266	4,421	2,759,594	170,541	3,090,927
Mullet								96	96
Perch		6,058		55,338	10,573	624	33,968	315	106,876
Pike			1,104						1,104
Pompano, California					22		215		237
Rock Bass						2,162	17,246	34,066	53,474
Rockfish	2,480	18,989		168,841	549,880	122,193	262,590	144,698	1,269,671
Sablefish		43,170		23,631	112,630		225,429	7,358	412,218
Salmon			20,144		11,863				32,007
Sand Dab		50		140,193	11,191		7,028		158,462
Sardine			18,302,099	6,251,517	85,381,166	308	231,378,256	8,653,935	349,967,281
Sculpin						212	9,465	1,587	11,264
Sea Bass, Black						503	98,177	40,894	139,574
Sea Bass, Shortfin								136	136
Sea Bass, Totuava							884,212	24,596	908,808
Sea Bass, White					160	8,317	21,735	1,256	31,468
Sea Trout		25							25
Shad			89,745		27				89,772
Shark				89,705	350	12,065	52,603	2,893	157,616
Sheepshead						3,082	62,522	815	66,419
Skate				96,232	6,949		3,297	2,455	108,933
Smelt		6,036		106,282	14,660	3,910	80,871	2,590	214,349
Sole		903		2,204,937	31,778	107,635	3,337	958	2,349,548
Split-tail			21,487						21,487

Striped Bass			167,951	18,212			7		186,170
Sucker			19,951						19,951
Swordfish, Broadbill								511	511
Tomcod				475					475
Tuna, Albacore							581,269		581,269
Tuna, Bonito						50	34,488	163,625	198,163
Tuna, Skipjack							876,616	356,074	1,232,690
Tuna, Yellowfin							3,557,350	7,660,422	11,217,772
Turbot				16,925	194		6		17,125
Whitebait	21,462	21,015		9,725	747				52,949
Whitefish						3,960	10,031	9,442	23,433
Yellow-tail							324,939	384,477	709,416
Miscellaneous Fish		927	133	42,312	200	109	1,678		45,359
Crustacean:									
Crab	1,814	50,764		1,237,122	18,446				1,308,146
Crab, Rock							3,405		3,405
Lobster, Spiny						9,870	70,768	393,392	474,030
Prawn					63				63
Shrimp				164,524			1		164,525
Mollusk:									
Abalone					202,950	97,625	150		300,725
Clam, Cockle				25,693			6,452		32,145
Clam, Gaper		1,560		572					2,132
Clam, Pismo					7,620	31,994			39,614
Clam, Soft-shell				43,063					43,063
Clam, Washington		14,071		429					14,500
Octopus		1,196		3,967	7,482		4		12,649
Oyster, Eastern				116,046					116,046
Oyster, Japanese				30,160					30,160
Oyster, Native				90					90
Snail				200					200
Squid					178,507		1,955		180,462
Total pounds	29,885	250,396	18,744,356	11,765,902	86,837,075	483,817	242,163,979	18,299,552	378,574,962

*Some fresh fish importations from foreign countries included. See importation tables.

23006 11-35 3M

BUREAU OF PATROL

E. L. MACAULAY, Chief of Patrol ..... San Francisco

CENTRAL DISTRICT (Headquarters, Sacramento)

S. H. Lyons, Inspector in Charge ..... Sacramento
Jos. H. Sanders, Captain Northern Division ..... Sacramento
S. R. Gilloon, Captain Southern Division ..... Fresno
John O'Connell, Captain ..... Modesto
O. P. Brownlow, Captain ..... Bakersfield
A. H. Willard, Captain ..... Nevada City
----------, Sergeant ..... Redding

J. E. Newsome, Captain, Newman
S. J. Carpenter, Captain, Maxwell } Special Duty
E. W. Smalley, Captain, Hanford

WARDENS (Northern Division)

Roy W. Anderson ..... Red Bluff
W. J. Black ..... Vallejo
L. W. Dinsdale ..... Yuba City
C. O. Fisher ..... Susanville
C. L. Gourley ..... Westwood
Alvin Granstrom ..... Loyalton
Brice Hammack ..... Yreka
Earl Hiscox ..... Grass Valley
Wm. Hoppe ..... Lodi
A. A. Jordan ..... Alturas
Paul Kehrer ..... Fall River Mills
Taylor London ..... Oroville
L. W. Longeway ..... Sonora
Charles Love ..... Redding
Leslie Mercer ..... Quincy
Nelson Poole ..... Sacramento
Albert Sears ..... Placerville
Chas. Sibeck ..... Sacramento
R. L. Sinkey ..... Woodland
Fred R. Starr ..... Macdoel
Vernon Sutton ..... Weaverville
R. A. Tinnin ..... Camptonville
E. C. Vail ..... Willows
H. S. Vary ..... Walnut Grove
Edwin O. Wraith ..... Chico

(Southern Division)

Lester Arnold ..... Bakersfield
H. E. Black ..... Madera
Clarence Brown ..... Mariposa
F. A. Bullard ..... Reedley
Ray J. Bullard ..... Porterville
M. S. Clark ..... Merced
Cliff Donham ..... Coalinga
Wm. Hoppe ..... Lodi
F. F. Johnston ..... Auberry
R. J. Little ..... Jackson
Walter I. Long ..... Woodlake
Geo. Magladry ..... Modesto
C. S. Donham ..... Angels Camp
J. W. Thornburg ..... Markleeville
Roswell Welch ..... Kernville

COAST DISTRICT (Headquarters, San Francisco)

K. P. Allred, Inspector in Charge ..... San Francisco
Wm. J. Harp, Captain Northern Division ..... Ukiah
Wm. Lippincott, Captain Southern Division ..... San Francisco
J. D. Dondero, Captain ..... Eureka
Henry Lencioni, Captain ..... Santa Rosa
Ralph Classic, Captain ..... Monterey

WARDENS (Northern Division)

W. C. Blewett ..... Crescent City
Earl Caldwell ..... Eureka
Ray Diamond ..... Willits
Scott Feland ..... Fortuna
E. R. Greenleaf ..... Monterey
J. H. Groves ..... Cloverdale
J. W. Harbuck ..... Napa
Ovid Holmes ..... Fort Bragg
E. J. Johnson ..... Garberville
Wm. F. Kaliher ..... Fortuna
Bert Laws ..... San Anselmo
Earl Macklin ..... Ukiah
Leo Mitchell ..... Point Arena
K. J. Ransdell ..... Nice
Victor Von Arx ..... Santa Rosa
L. J. Weseth ..... Monterey
R. J. Yates ..... San Rafael

(Southern Division)

C. M. Bouton ..... San Francisco
C. L. Bundock ..... Oakland
Ed Clements ..... San Rafael
T. K. Duncan ..... Concord
Chas. England ..... San Rafael
Fred W. Hecker ..... San Luis Obispo
C. E. Holladay ..... San Jose
John Hurley ..... Pismo Beach
Mansfield Joy ..... San Francisco
McPherson Lough ..... Palo Alto
F. J. McDermott ..... Santa Cruz
Tate Miller ..... Moss Landing
C. R. Peek ..... San Mateo
Orben Philbrick ..... Pacific Grove
Fred H. Post ..... Salinas
Lee C. Shea ..... San Francisco
Geo. Smalley ..... Richmond
Paul L. Turner ..... Paso Robles
J. P. Vissiere ..... Watsonville

SOUTHERN DISTRICT (Headquarters, Los Angeles)

C. S. Bauder, Inspector in Charge ..... Los Angeles
LaRue Chappell, Captain Western Division ..... Los Angeles
E. H. Ober, Captain Eastern Division ..... San Bernardino
L. T. Ward, Captain ..... San Diego
C. H. Groat, Captain ..... Terminal Island
---------- Sergeant ..... Santa Barbara
---------- Sergeant ..... Indio
---------- Sergeant ..... Bishop

SOUTHERN DISTRICT (Western Division)

A. R. Ainsworth—Santa Maria	E. H. Glidden—San Diego
R. E. Bedwell—Ventura	W. L. Hare—Santa Ana
E. A. Chan—Terminal Island	H. C. Jackson—Santa Barbara
Ray Ellis—Newport Beach	Carmi Savage—Los Angeles
Walter Engelke—Terminal Island	C. L. Towers—Los Angeles

(Eastern Division)

A. F. Crocker—Bridgeport	R. C. O'Connor—Bishop
J. H. Gyger—Perris	W. S. Talbott—Forest Home
Geo. Johnson—El Centro	C. J. Walters—Independence
Theo Jolley—Idyllwild	E. L. Walker—Independence
W. C. Malone—San Bernardino	

LAUNCH PATROL

Motor Vessel "Bluefin," Terminal Island
Launch "Albacore,' Monterey
Launch "Shrapnel," Sacramento
Launch "Quinnat," San Rafael
Launch "Hunter," Vallejo
Launch "Rainbow," Walnut Grove
Launch "Silverside," Eureka

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